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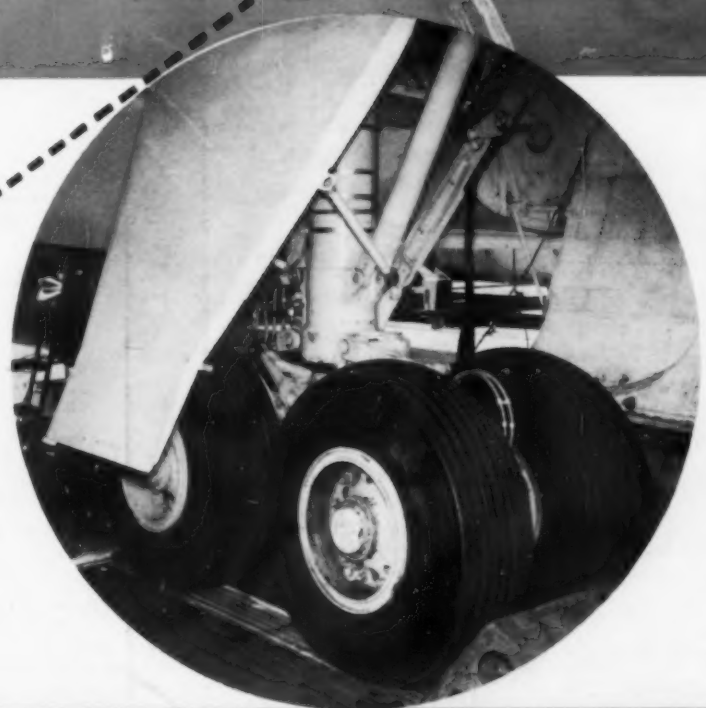
AUGUST 1961



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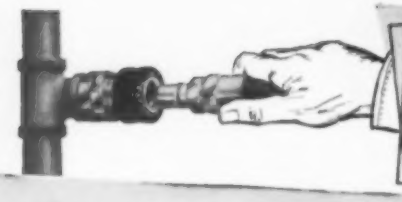

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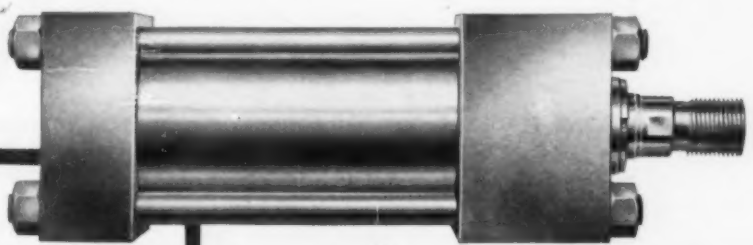

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VOLUME 14/NUMBER 8

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In the Hydraulic Hose section are descriptions of Anchor Super-Spiral 4 Ply and 6 Ply Wire Wrap Reinforced High Pressure hose; High Pressure Three Heavy Wire Braid hose; Styles CHX and LHX; High Pressure Two Wire Braid hose, Style C (SAE 100R2); Medium and Low Pressure One Wire Braid hose, Style F (SAE 100R1); Hi-Burst Two Rayon Braid hose (SAE 100R3); Standard Two Rayon Braid hose; Spiral Wire Low Pressure Suction hose (SAE 100R4); and High Pressure Two Wire Braid hose for Non-Flammable Hydraulic Fluids (Phosphate Ester), Style C75.

Anchor Hydraulic Hose Assemblies with Anchor Pressed-On Couplings for unexcelled dependability, longer life and peak performance on virtually all fluid power applications are shown with their respective hose styles.

Anchor Reusable Couplings for high, medium and low pressure use with Two and One Wire Braid Rubber Covered hose; and Hi-Burst and Standard Two Rayon Braid Hose are described. In addition, Anchor Duloc Couplings, for use with Styles QW (SAE 100R5) and Style QWR hose; and Anchor Clamp Type Couplings which attach easily to Wire Braided or Rayon Braid hose are also included.

Anchor Fittings are described and illustrated, and include Adapter Unions, 37° Flare Straight and Angle Adapters and adapter unions; Pipe Fittings; SAE Straight Thread "O" Ring Boss Type Fittings.

Anchor 4-Bolt Split-Flange "O" Ring Head Clamp Type Couplings for use with three wire braid, two wire braid, one wire braid, Hi-Burst two rayon braid, standard two rayon braid, and suction hose spiral wire are pictorially described, with illustrations of available flange stems in straight, 22½°, 30°, 45°, 60°, 67½°, and 90° angles.

Anchor 4-Bolt Split-Flange Pressed-On Hose Assemblies for 4 Ply and 6 Ply Super-Spiral Wire Wrap Reinforced hose, three wire braid, two wire braid, one wire braid, and spiral wire suction hose are also included, together with flange stem styles.

A section on Anchor Freon Hose Assemblies and angle couplings are covered, together with specifications. Anchor Hydraulic Steering and Power Steering Hose Assemblies and Automotive Hose Couplings are also described.

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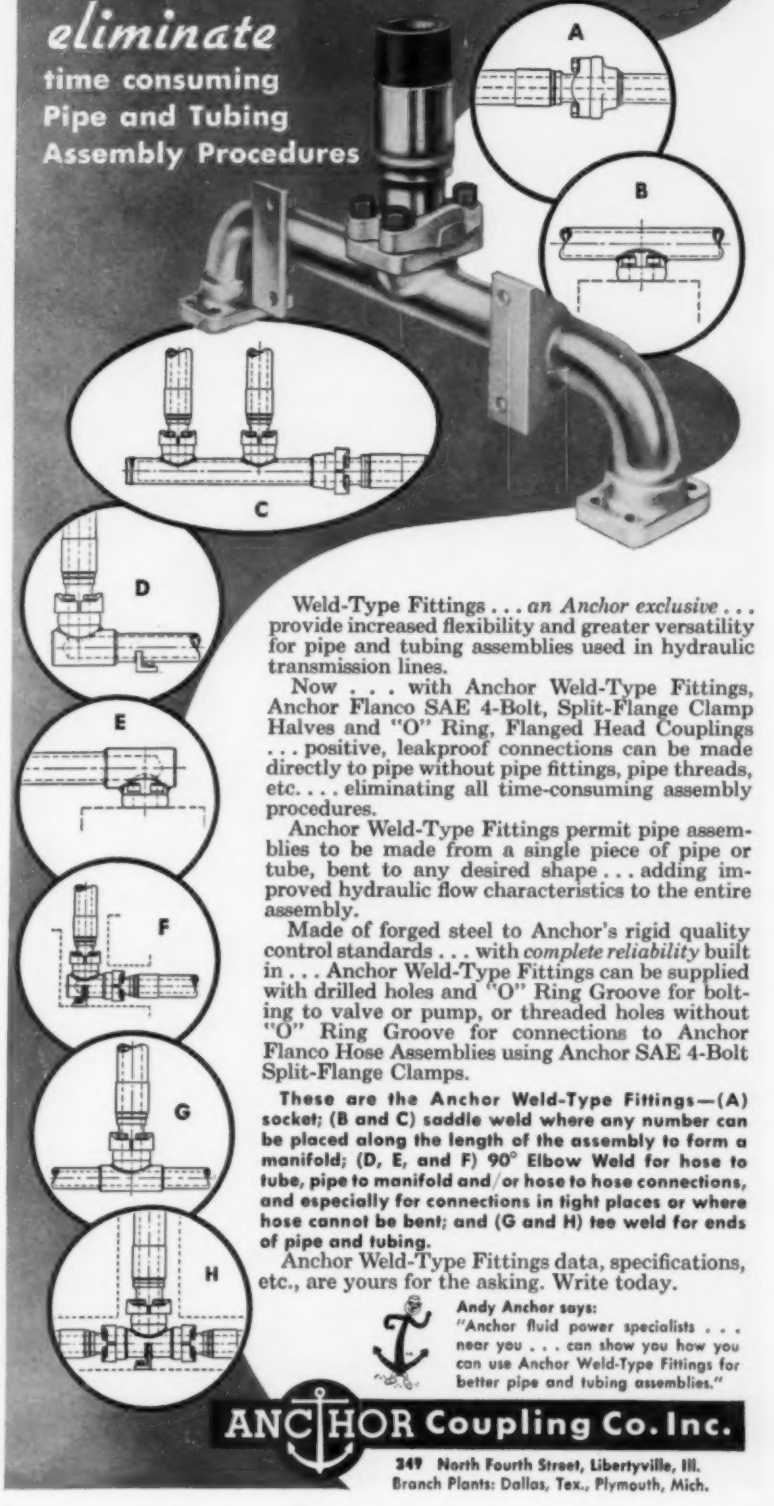

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...Fluid Power news

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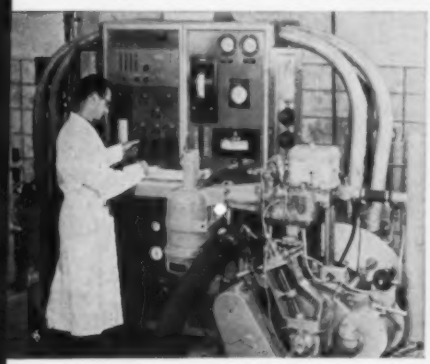
Report No. 12,400 From Oilgear *Application-Engineering* Files

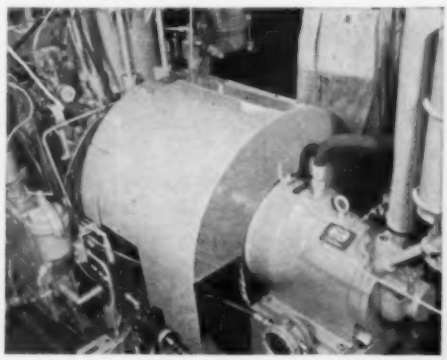
HOW OILGEAR-ESSO RESEARCH TEAMWORK SOLVED NEED FOR MORE COMPACT, LOWER COST, RELIABLE, HIGHLY ACCURATE, DYNAMOMETER AND STARTER SYSTEMS

USER: *Esso Research and Engineering Corp., Linden, New Jersey*

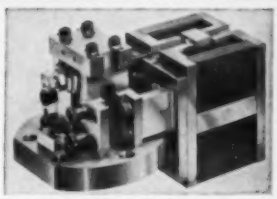
PROBLEM: New Equipment to conduct the exhaustive, standardized performance tests on all new fuels and lubricants, as required by the oil companies and engine manufacturers — to guarantee top-quality petroleum products for optimum consumer engine performance. These extended tests — carefully recorded and regulated from operating control centers — are performed with *standard test* engines coupled to load-absorbing dynamometers. Cradled, expensive electrical load absorbers were previously used to provide test engine control.

ESSO RESEARCH REQUIREMENTS FOR A NEW DYNAMOMETER SYSTEM WERE: 1. Sharply reduce installed cost and valuable test floor space. 2. Insure absolutely reliable, precise, loading and speed control over continuous periods up to 1,000 hours per test. 3. Simplify test engine starting methods — normally 50-hp motors are used to overcome high starting torques, due to heavy flywheels and high internal friction. 4. Long life, maximum trouble-, and maintenance-free durability.





LEFT: One of the Oilgear-Esso Research centralized control centers for complete recording, regulation, control, and operation of two test engines, and the Oilgear servo-valve-controlled Dynamometer and Starters connected to them. **RIGHT:** Rear view of 5¾" bore by 8" stroke, Standard Single Cylinder Test Engine with Oilgear servo-valve-controlled Dynamometer/Starter. This efficient, compact, Oilgear pump/motor unit is shaft-coupled to the test engine . . . cranks the engine for starting — then absorbs all power produced during testing. Other system equipment — Oilgear servo-valve "Power Paks" that regulate the loads imposed on the test engines and Oilgear remote, air-controlled Type "DA" Variable Displacement Pump used for starting the test engines — are mounted on the floor above to free valuable test floor area for additional testing units.



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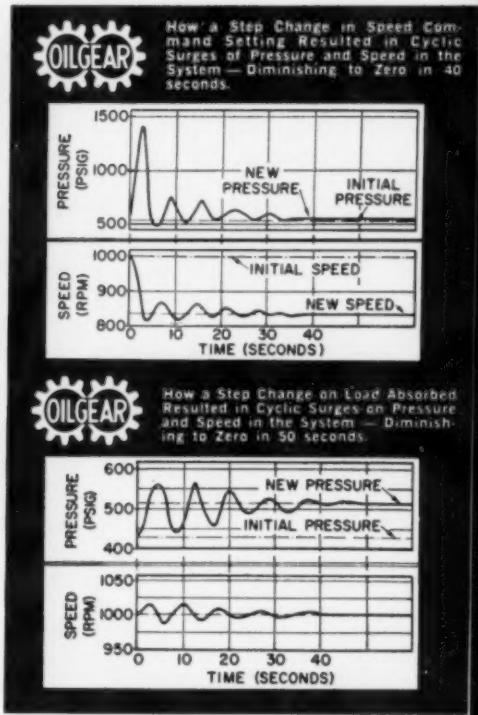
*A *Division of The Oilgear Company*



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ESSO RESEARCH REPORTS — *"Other than installed cost and space saving, the prime requirement of this dynamometer was to maintain a constant speed for variations in temperature, engine torque, etc. This system maintains an accuracy of 1 rpm at an engine speed of 1000 rpm — or a speed accuracy of 0.1%.*

Information contained in this Fluid Power News Report is condensed from a paper entitled, "Electro-Hydraulic Dynamometer and Starter for Laboratory Test Engine" — by J. W. Broome, Chief Engineer, Servocontrol Division of The Oilgear Company, and R. L. Van Voorhies, Senior Engineer, Mechanical Division, Esso Research and Engineering Company . . . presented at the NCIH — Chicago, Illinois. OILGEAR — SERVOCONTROL *are trademarks of The Oilgear Company.*

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FLUID POWER LINES

from editor to reader

. . . THE BEST IS YET TO BE

Like tax time, publication deadlines have a way of coming at a constantly accelerating rate. That must be well understood by all those who entered—or intended to enter—the HYDRAULICS & PNEUMATICS Prize Paper Contest. The entries have now been judged and winning papers will be presented in the October issue. As in years past, we expect that issue to be particularly valuable because of the high quality of the Contest entries. Other winning papers and those receiving honorable mention will be published in future issues. They promise some excellent editorial material in the coming months.

Not only do these papers represent design ingenuity on a wide range of fluid power equipment, they also show facility in handling basic principles to achieve unusual solutions to design problems. Here's a look at what's coming:

- Unless you've designed one, you'll be surprised to learn how many operations there are in starting and stopping a 1000-hp engine compressor in a gas pipeline station. One paper describes the controls—an all-pneumatic system, partly actuated by instrumentation signals.
- How hot will it run? You'll be able to answer that question before a machine is actually built, using the techniques explained in one paper on oil heating and temperature rise.
- High temperature components are the objectives of many design programs in the aerospace field. One of the Contest entries presents a review of design tips for seals, valves, solenoids, and filters for fluid temperatures to 450F, 650F ambient.
- Meanwhile, back on earth, designers of agricultural tractors have found that the number of hydraulic functions has increased to the point where a central, constant pressure system is the most effective way of providing hydraulic power. One paper describes the design features of this system and its components.
- Low pressure (5 psi), diaphragm-actuated valves and electrical switches can be used effectively in machine tools and other pneumatic systems. This is illustrated in one paper which shows circuits and design arrangements to use these components.

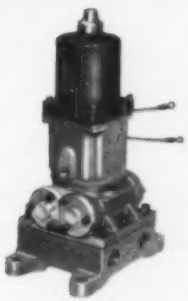
These are a few previews of future articles in H&P. They're part of the reason why the best is yet to be.

Allan E. Morris

Editor

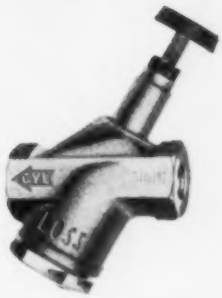
The stock shelves at **Ross** include more different air valves than any other stock shelves in the valve world

Do you know these air controls by Ross?



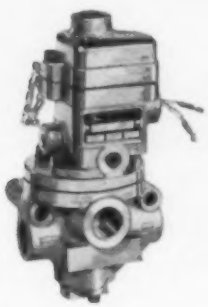
50 Million Cycles in Tests

Ross Goldmodel. A lightning fast, base mounted valve with its solenoid immersed in oil to run cool for long, long life. Full JIC. 3-way, 4-way and 4-way 5 port models. ¼" through 1¼".



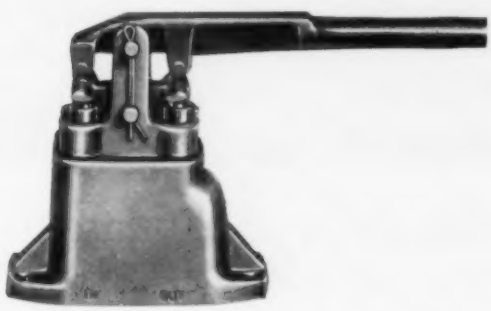
Control Cylinder Speed

Speed Control Valve. The adjustment screw directs air through an orifice that's engineered to give fine shadings of control at either high or low flow rates. ¼" through 1¼".



Does a Big Valve's Work

"Headline Series". Highest capacity valve-size for valve-size of any valve we've seen. Use a smaller, economical inline valve to do a bigger, more expensive valve's work. Fast. S-way, 3-way, 4-way. ¼" through 1½".



Especially for Tough Duty

Ross #100 series. Rough, tough jobs call for this valve which can pass most dirt and foreign matter with no trouble. Few moving parts and short poppet travel makes it especially wear resistant.

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The most complete line of air controls in the world

ROSS OPERATING VALVE COMPANY

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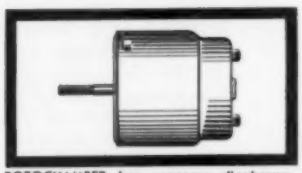
Quality materials and craftsmanship... Bendix-Westinghouse Power Cylinders

You can count on Bendix-Westinghouse for the best in design, materials, and manufacture. Our power cylinder capabilities result from actual experience in every imaginable application—medium, heavy-duty, standard, and special. Our comprehensive inventory of machined parts for standard units, combined with our manufacturing flexibility, means fast delivery to meet your needs. In addition to the broad range of standard models, we can "customize" to your requirements with specialized sizes and mounts. Write today for complete information on the quality advantages you enjoy with Bendix-Westinghouse engineering and manufacturing.



ROTOCHAMBER has neoprene diaphragm, delivers from 900 to 5000 pounds force at 100 psi air pressure.

ROBOTAIR CHAMBER has optional rubber or neoprene diaphragm, delivers from 300 to 3600 pounds force at 100 psi air pressure.

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INDUSTRIAL PRODUCTS

Bendix-Westinghouse Automotive Air Brake Company, Elyria, Ohio

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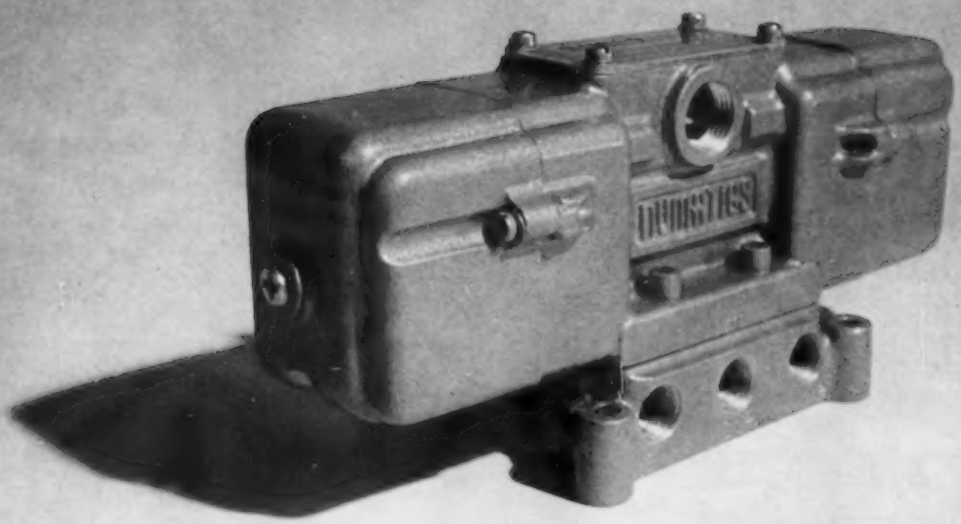
Circle 80 →

the precision air valve



with the stainless steel stomach!

Air lines get dirty even in the best of plants. Dirt stops most valves, and production. But a Numatics valve keeps on working.

We don't say it's impossible to jam a Numatics valve but you can't hurt it with dirt. Why? The hardened, stainless steel, lapped spool and sleeve—unique in the industry. No resilient seals to get chewed up, or seize after long shut-downs. Working smoothly with millionths of an inch clearance, the stainless sleeve and spool—with razor sharp lands—will digest a diet of cast iron, aluminum, and steel chips, and foundry sand.

A Numatics valve will keep on working (even improve with service) under conditions that would stop an ordinary packed valve dead.

Any wonder we call Numatics valves the most reliable in the industry?

Buy Numatics—and relax.

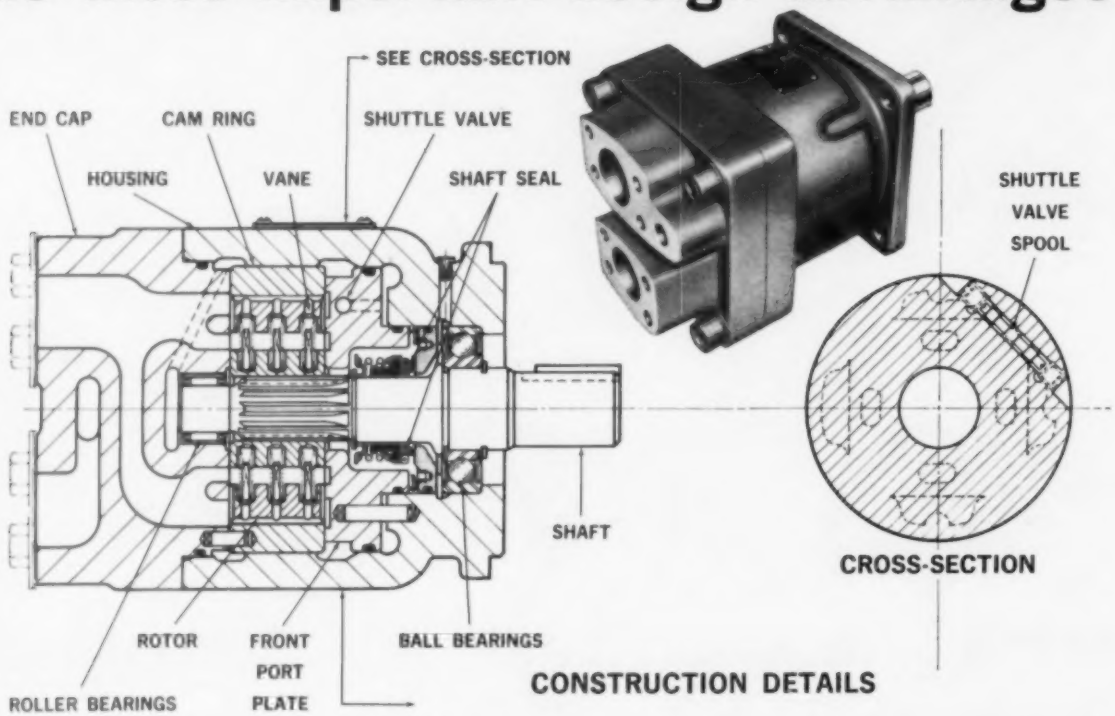
The lapped spool and sleeve.
It works, and works, and works.

NUMATICS, Inc.

Highland, Michigan

FOR HYDRAULIC ROTATING POWER:

New 2000 psi balanced-vane fluid motor has these important design advantages



By: Robert A. Manogue

Pumps/Controls Product Manager
Denison Engineering Division
American Brake Shoe Co.

Today's demands for efficient, low cost hydrostatic power transmissions are growing rapidly. Design engineers have, in turn, demanded reliable vane-type fluid motors that are compact, lightweight and efficient for their hydraulic rotating power needs.

COMPACT 1 LB. PER HP RATIO

The new Denison "M1D" Series floating cartridge, balanced vane/balanced rotor fluid motor shown here is one of 5 sizes available. They are excellent choices for service up to 2000 psi at speeds up to 2000 rpm and for hp ranges up to 75. Unit size is a highly compact 11 11/16" long by 6 1/8" square—including normal keyed shaft extension. Weight is under 75 lbs., affording an efficient 1 lb. per horsepower ratio.

The five motor sizes offer a range of maximum theoretical torques of 1249, 1719, 1897, 2160 and 2345 lb.-in. at 2000 psi.

BALANCED VANES AND ROTOR

The pumping cartridge (vanes, rotor, cam ring, front and rear port plates) offers high efficiency power transmission through the motor shaft by symmetrically balancing the rotor and vanes 100% for axial thrust in both directions. Radial vane balance is approximately 80%—imparting a 20% pressure loading to the vanes as outward force against the cam ring to allow following the cam contour. By a unique combination of spring loading and oil porting control, vanes are balanced outward during their entire pumping period. This balance is produced by a combination of centrifugal force, spring loading and partial pressure loading.

Denison's vane design (two contoured sealing lips) also means effective control of cross-port leakage during work stroke on the major cam ring diameter. This leakage is normally inherent in most other fluid motors.

SHUTTLE VALVE CONTROLS CARTRIDGE LOADING

Clamping forces are imparted to these new M1D fluid motors by a unique shuttle valve, interconnected with the motor's two external ports. This valve shifts automatically to maintain the highest pressure available to the front port plate in order to control motor cartridge clearance axially. This special design always ports highest pressure oil to the rear of the front port plate—providing controlled cartridge loading that gives peak efficiencies and permits starting at any temperature.

FOUR OTHER DESIGN ADVANTAGES

Four other important features of the Denison M1D Series: (1) A 100 psi mechanical shaft seal. (2) Extremely wide bearing spacing to permit full shaft side loading—up to 795 lbs. side load. (3) Angular alignment is achieved by means of snug fit dowel pins. (4) Designed for SAE requirements—including 4-bolt SAE mounting pad, SAE spline shaft and SAE fluid connections. The main motor connections are 1¼" SAE fluid pads. Drain connection is 9/16"—18 UNF2B thread for ⅜" tube size.

NEW SPECIFICATIONS BULLETIN FOR DESIGNERS AND ENGINEERS

Write for your copy of Bulletin FMV-1 on new Denison M1D Series Vane-Type Fluid Motors. Includes specifications, operating and application data, performance figures on this new 2000 psi equipment.

DENISON ENGINEERING DIVISION
American Brake Shoe Company
1166 Dublin Road • Columbus 16, Ohio

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The **FLO-GARD** Cleanable Strainer is but one of the many new and exciting standard product lines being introduced by the Industrial Filter Division of the Warner Lewis Company. The Warner Lewis Company, long a leader in Liquid-Liquid separation, combines years of filtration engineering capabilities and production experience to specialize in liquid and gas filtration.

LONGER FILTER LIFE — Newest engineering advancement in filter manufacturing employs CORROSION-PROOF DuPont Delrin end caps, monel screen and no dissimilar metal connections insuring longer filter life.

SEAM WELDED SCREEN — The solid, full welded seam guarantees uniform filtration. Spot welded or lap seamed mesh can allow "leaks" between welds.

VERSATILE — filters all types of: LUBE OILS, CUTTING OILS, COOLANTS, HYDRAULIC OILS, AQUEOUS BASE (water glycols), SYNTHETICS (Phosphate Ester Base)

MALE and FEMALE THREADS IN ALL SIZES AND GRADES.

MEETS ALL J. I. C. STANDARDS

STD. MESH 100 WITH 40-60-80 MESH AVAILABLE AT NO ADDITIONAL COST

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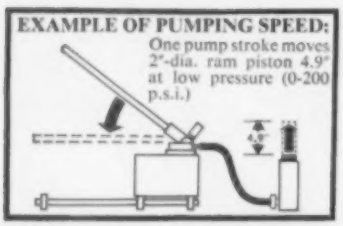
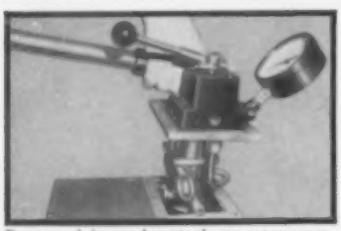
Get fast ram approach, save time with new 2-speed hydraulic pump





Pump, valving and controls mount on common cover plate; use with other reservoirs.

- **Delivers a big 7.35 cu. in. of oil per stroke at low pressure (0 to 200 p.s.i.)**
- **Delivers .294 cu. in./stroke from 200 to 10,000 p.s.i. for high force requirements**
- **For operating both single and double-acting cylinders**

Here is a compact, precision-built 10,000 p.s.i. 2-speed hand pump with the ability to deliver exceptionally high volume at low pressure for fast ram approach and return. Handle high-force requirements, yet waste no time getting the ram to the work! Choice of 2-way or 4-way control valve, mounted easily on cover plate; no exposed piping. Unit weighs only 34 lbs.

Ask your OTC distributor about the new OTC "Dualmaster" pump.

PRECISION HYDRAULICS DIVISION

RESEARCH ENGINEERING · DEVELOPMENT OTC

OWATONNA TOOL CO.

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DESIGNERS AND MANUFACTURERS OF QUALITY HIGH PRESSURE HYDRAULIC COMPONENTS

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LETTERS to the editor

Address your letters to: The Editor, HYDRAULICS & PNEUMATICS MAGAZINE, 812 Huron Rd., Cleveland 15, Ohio.

Aircraft and missiles at NCIH

TO THE EDITOR:

Members of our management are interested in obtaining information on the National Conference on Industrial Hydraulics. We are particularly interested in the aircraft and missiles section.

Would you be kind enough to forward the mailing address of the conference committee office, its officers, or any pertinent literature you feel will aid us.

ROCCO V. PORTANOVA
Public Relations
American Machine & Foundry Co.
Greenwich Engrg. Div.
Vandenberg Air Force Base, Calif.

We suggest you contact William Smith, National Conference on Industrial Hydraulics, Illinois Institute of Technology, Chicago 16, Ill. He can supply you with this information.

The conference is scheduled for October 16-17 at the Sherman Hotel in Chicago.

Needs gear motor

TO THE EDITOR:

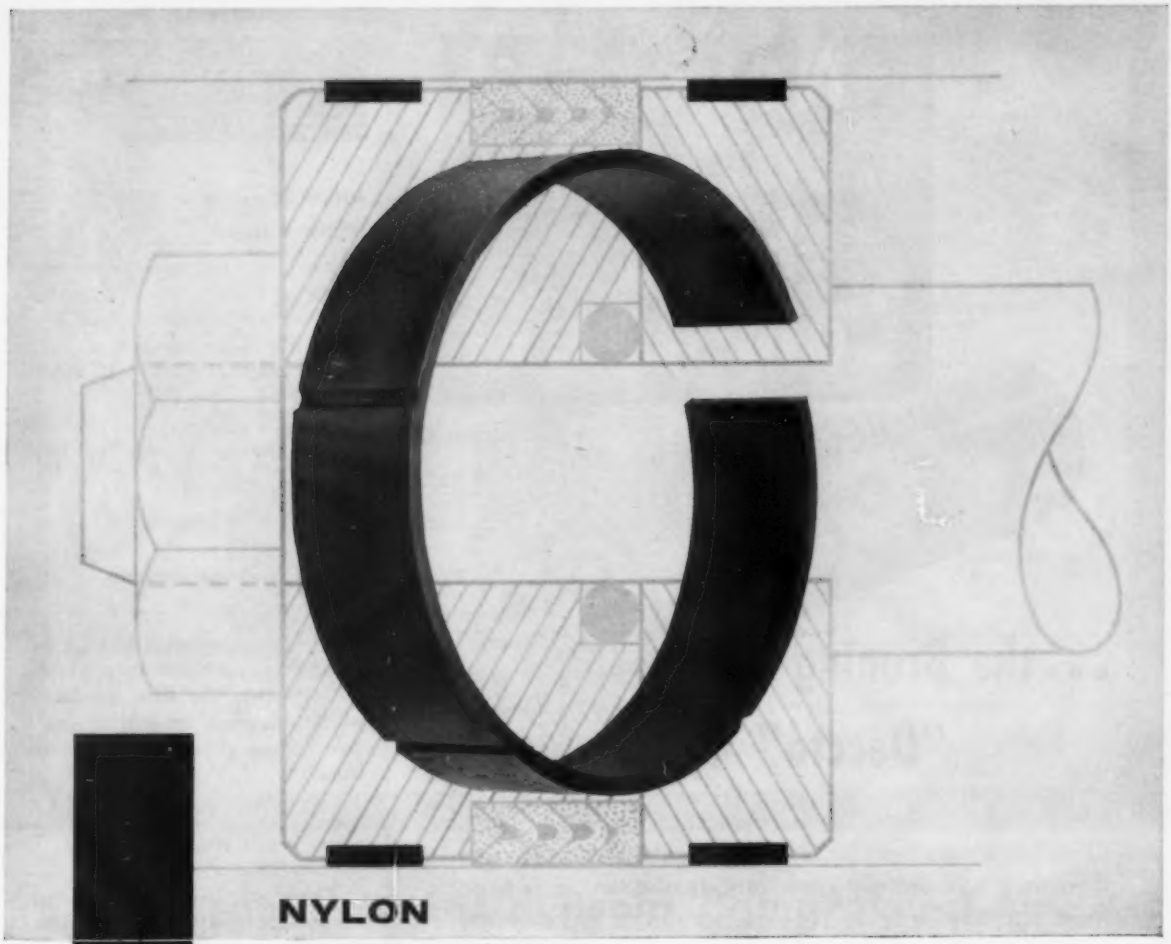
I would like to locate a manufacturer of gearhead motors. Specifications: 3-phase. 1 hp. Explosion-proof. Magnetic Brake. 1750 rpm. Gear Ratio 25:1. Hollow output shaft. Parallel offset. For use in vertical position.

Do you have an available list of manufacturers I might contact?

OLLIE G. DOUGLAS
Elizabethtown, Ky.

We suggest that you contact local representatives of the major electric motor manufacturers.

We're turning your letter over to our sister publication, POWER TRANSMISSION DESIGN. *Perhaps they can make further suggestions.*



NYLON WEAR RINGS for Hydraulic-Pneumatic Service

Now—prevent damage to piston cylinders with new Garlock Nylon Wear Rings. Greatly superior to materials previously used, the rings (designated Style 9003) are smoother and harder. This means that no foreign particles in the cylinder can be picked up or become imbedded in the ring and consequently score the cylinder walls. For you, it adds up to smooth, unhampered piston operation, greater overall efficiency, and longer cylinder and packing life.

Offer all the fine advantages of Nylon. Garlock Nylon Wear Rings provide satisfactory service in temperatures as high as +350°F. They are unaffected by the normal fluids used in hydraulic cylinders. They exhibit greatly-improved wear qualities and life expectancy. Garlock Nylon Wear Rings are available in a wide range of sizes for new equipment, and will normally fit existing grooves in present equipment. You can order Nylon Wear Rings in nominal diameters (inches) from 2.005/2.010 to 7.005/7.015, and in widths (inches) from .500/.490 to .625/.615, depending on diameters. Special sizes also available.

For more information, call your local Garlock representative. He is at the nearest of the 26 Garlock sales offices and warehouses throughout the U.S. and Canada. Or, write for Catalog AD-179. Garlock Inc., Palmyra, N. Y. **Canadian Div.:** Garlock of Canada Ltd. **Plastics Div.:** United States Gasket Company. **Order from the Garlock 2,000** . . . two thousand different styles of Packings, Gaskets, Seals, Molded and Extruded Rubber, Plastic Products.

As bearings to prevent wear between piston and cylinder (top), Garlock Nylon Wear Rings are gaining fast acceptance among leading manufacturers of hydraulic-pneumatic equipment, such as Hough Loaders (below).

GARLOCK

Never Replaced by a Competitor

...the Bruning "Deccto" Cylinder

The fact that "Deccto" cylinders outperform their competition has always been far more important to our customers than their substantially lower cost. In the ten years since these outstanding hydraulic and pneumatic cylinders became standard original equipment on countless installations coast-to-coast, to our knowledge none has yet been replaced by a competitive unit.

We believe the "Deccto" is the most efficient, versatile and competitive cylinder on the market today. It is engineered and manufactured to such advanced concepts that it routinely outperforms conventional, commercial, industrial and military "specification" cylinders weighing two to three times more and costing two to ten times as much.

TEST THE DECCTO YOURSELF. IT WILL PAY YOU MANY TIMES OVER TO TAKE THE TIME TO DO SO.

- 1.5" through 4" bore ((mirror finished)
- 5,000 - 8,000 P. S. I.
- J. I. C. Interchangeability
- Unexcelled for compactness and installational flexibility
- Either single or double action
- Best **value** on the market

Call collect or write today. "Deccto" cylinders could be saving you thousands of dollars. Our files support this claim, and we will be happy to send you full particulars.

THE BRUNING COMPANY — LINCOLN, NEBRASKA

Phone – HE 5-3511 • TWX – LI 8151

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LETTERS

Air diaphragm motors

TO THE EDITOR:

Could you please send me the names of companies that make small air diaphragm motors? We would like to use 0-15 psig air and stroke various ranges 0 to 1", 1½", 2".

ROBERT I. BUCKALTER
Test Engineering—Titan Prod. Div.
American Machine & Foundry Co.
Greenwich, Conn.

Names have been sent.

Wants leakage figures

TO THE EDITOR:

It is recognized that leakage in pneumatic systems is very wasteful of power. Is data available which dollarizes the cost of various leakage rates in typical systems?

E. F. PAIN
Vice President—Sales & Engineering
Aero Supply Mfg. Co. Inc.
Corry, Pa.

We've sent names of several compressor and pneumatic component manufacturers who have published information on air system leakage.

Cylinder testing

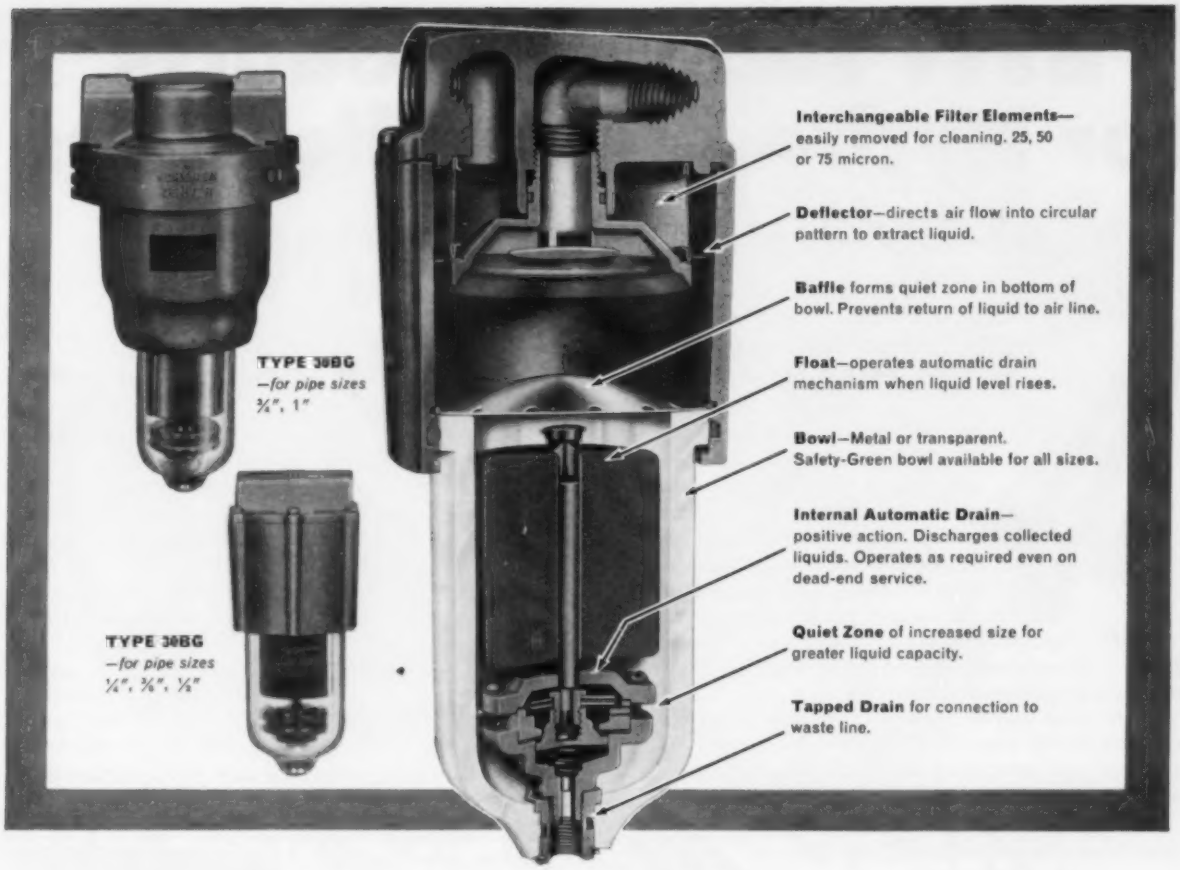
TO THE EDITOR:

We are interested in equipment for testing steel cylinders with hydrostatic pressure at 1500 psi. These cylinders are filled with water and then pressure is applied. The water pump must be driven by electric motor.

Can you tell us the names and addresses of manufacturers of this equipment? Your answer will be greatly appreciated.

ING. A. MAYERSON
Maquinaria y Accesorios
Luis Moya 59, Mexico, D. F.

Equipment for hydrostatic testing is usually engineered special for each application. There are a number of companies that can do this. We have suggested a company that can assist you in designing and building the equipment. ▼▼▼


TYPE 38BG
—for pipe sizes
¾", 1"
TYPE 38BG
—for pipe sizes
¼", ⅜", ½"
Interchangeable Filter Elements—easily removed for cleaning. 25, 50 or 75 micron.
Deflector—directs air flow into circular pattern to extract liquid.
Baffle forms quiet zone in bottom of bowl. Prevents return of liquid to air line.
Float—operates automatic drain mechanism when liquid level rises.
Bowl—Metal or transparent. Safety-Green bowl available for all sizes.
Internal Automatic Drain—positive action. Discharges collected liquids. Operates as required even on dead-end service.
Quiet Zone of increased size for greater liquid capacity.
Tapped Drain for connection to waste line.

Norgren Automatic-Drain Compressed-Air-Line Filters provide FULL-TIME protection

The purpose of a compressed-air-line filter is to remove liquids and solids from the air-stream so that they cannot clog, corrode or damage air-powered equipment. Your equipment needs this protection *full-time.*

Manual drain filters are often neglected . . . are not drained as often as they should be. When excess liquid collects in the bowl these filters no longer do the job. Liquid in the air-stream passes right on through to your air tools, cylinders and other air-operated equipment.

This cannot happen with Norgren Automatic-Drain Filters. They empty themselves as often as required . . . never get too full. Operation is determined entirely by the need for draining; and not, as with some makes, by changes in air pressure. Although an automatic-drain filter costs more than a manual drain filter, Norgren Automatic-Drain filters protect your air-powered equipment *full-time* day and night, year-in-year-out. They prevent costly wear and damage to your equipment and eliminate man-hour costs for manual draining.

Order Norgren Automatic-Drain Filters from your nearby Norgren Representative, listed in the telephone directory—or write factory for catalog.

FOUNDED IN 1925

C. A. NORGREN CO.

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B&W Tubular Products for Hydraulic Applications

Job-Matched For Trouble-Free, Dependable Service

LECTROSONIC Cylinder Tubing (special smooth inside finish)

Hydraulic engineers can rely on B&W Special Smooth Inside Diameter LECTROSONIC Tubing for all types of hydraulic cylinder applications because it has guaranteed maximum average micro-inch finish, uniform wall thickness, close inside diameter tolerance, is light in weight, yet has high strength.

Quality controls include 100% continuous Ultrasonic Inspection in addition to four other checks on the weld to assure dependability.

Made from carbon steel, electric-resistance-welded, and cold drawn. Sizes from ½ inch to 3⅞ inches outside diameter, and depending on specific outside diameter, wall thicknesses from .028 to .188 inch.

Seamless Mechanical Tubing for Cylinders

Used generally for the manufacture of high-pressure, heavy-wall cylinders. Supplied cold-drawn or roto-rocked, with surfaces ready for the final finishing operations needed for cylinders of this type. Available in B&W's full line of carbon, alloy and stainless steels. Sizes up to 9¼ inches outside diameter in a wide range of wall thicknesses.

Welding Fittings and Flanges

The dimensional accuracy of B&W Seamless Welding Fittings and Forged Steel Flanges is the key to economical pre-fabrication and installation of process piping. They are available in a complete range of types in a full size range, in carbon steel and the B&W Croloys (alloy and stainless steels).

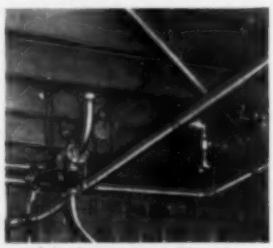
- Elbows
- Returns
- Reducers
- Tees
- Caps
- Stub Ends
- Flanges
- Saddles
- Laterals
- Bull Plugs
- Nipples
- Crosses

LECTROSONIC J.I.C. Hydraulic Line Tubing

B&W LECTROSONIC Hydraulic Line Tubing for use in all types of hydraulic equipment, such as automotive applications, machine tools, farm implements, materials handling equipment, and road building machinery, is produced to the new J.I.C. standards adopted in 1959, which now permit the use of welded tubing in such service.

B&W LECTROSONIC Hydraulic Line Tubing—manufactured under the most exacting quality control methods in the industry—meets the new J.I.C. standards in every respect. Available in carbon steel in all sizes and gages for the working pressure ranges in the standards.

Pressure Piping



B&W Pressure Pipe is produced under close metallurgical and manufacturing control to assure ease of fabrication and long life under all types of service conditions. It is available in a complete range of stainless, alloy and carbon steels for all types of industry applications.

Seamless Pressure Piping is produced in sizes through 8 inch IPS in all normal schedules, in carbon, alloy, and stainless steels. Welded Pressure Piping is produced in the stainless steels through 4 inch IPS in schedules 5 and 10, and through 2 inch IPS in schedule 40.

For bulletins and further information, write to The Babcock & Wilcox Company, Tubular Products Division, Beaver Falls, Pennsylvania.

B&W

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TUBULAR PRODUCTS DIVISION

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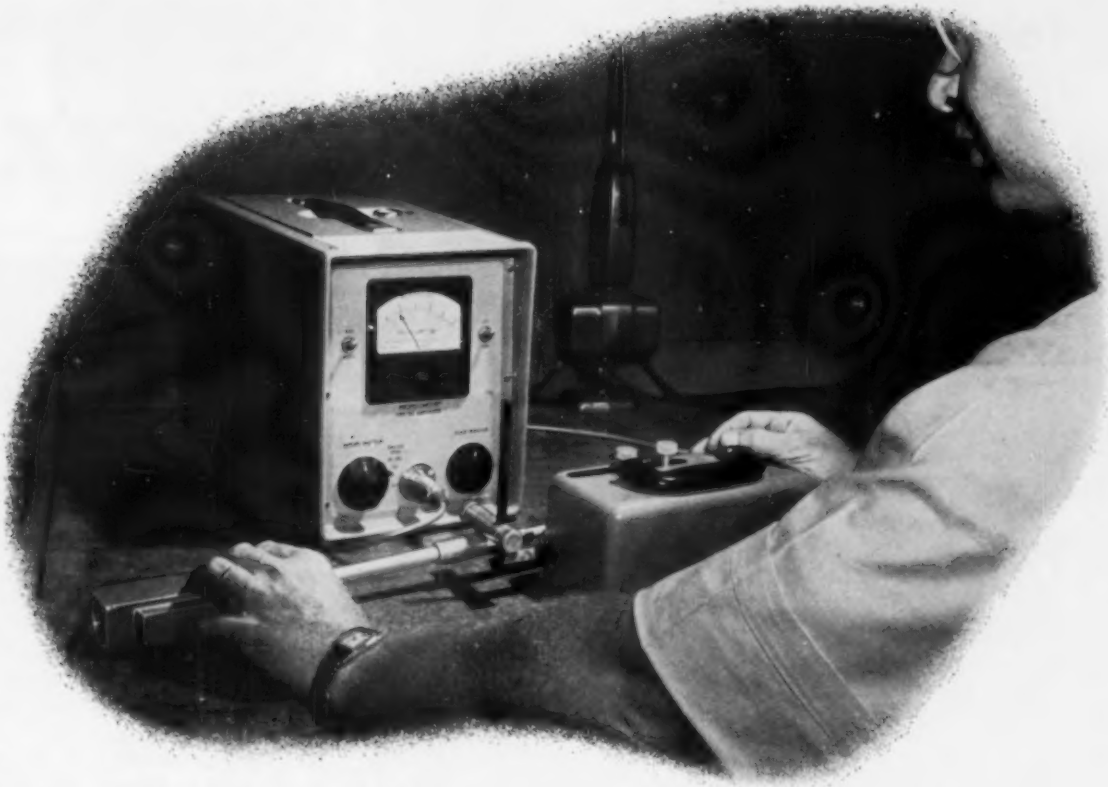
Seamless and welded tubular products, solid extrusions, rolled rings, seamless welding fittings, forged steel flanges—in carbon, alloy and stainless steels and special metals



extra care for longer valve life!

The bores of all Valvair Speed King® valves are processed to a surface finish of 20 microinches or better... stems are held to 10 microinches.

To maintain its established standards of surface finish, Valvair precision-machines, then hones every main valve bore... grinds, hard-chrome plates, then polishes each stem. Prior to assembly, bores and stems are checked with a surface measuring instrument to be absolutely certain that surface finish meets Valvair's rigid requirements.

This painstaking attention to product quality is one of the reasons for Valvair's products' multi-million cycle dependability and is your guarantee of Valvair performance and service life. If you stake your reputation on the design, construction or operation of air controlled machinery, can you afford to use less than the best... the most dependable control valve components? Your nearby Bellows-Valvair Field Engineer can tell you more about Valvair quality and versatility. Call him today. Or, for more information, write Bellows-Valvair, Akron 9, Ohio, Dept. AH-861.

Bellows-Valvair

AKRON 9, OHIO

DIVISION OF INTERNATIONAL BASIC ECONOMY CORPORATION (IBEC)

8174

Ask for performance curves and specifications on the new H-P-M relief valves. See for yourself the built-in values.

Just how important is the close control of operating pressures in your circuit? H-P-M relief valves offer remarkably low differential between cracking and override pressures in a range from 0 to 3000 psi. This built-in accuracy gives closer control of machine motions; protects the system from damaging override pressures; provides the instant reaction you need for better machine operation. H-P-M relief valves are performance proven in industry, in ground support hydraulics, in just about every field of hydraulics. Available in ⅜", ¾" and 1¼" sizes, interchangeable with industry standards, subplate mountings, 3000 psi, 6 gpm to 65 gpm capacities. Write for full information.

⅜" Relief Valve
3000 psi, 6 gpm

¾" Relief Valve
3000 psi, 20 gpm

1¼" Relief Valve
3000 psi, 65 gpm

H-P-M DIVISION • Koehring Company
Mt. Gilead, Ohio, U.S.A.

HPM

H126

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FLUID POWER FORUM

Each month HYDRAULICS & PNEUMATICS surveys readers for their experiences and opinions in fluid power design.

• ***What improvements would you like to see in fluid power components?***

I need a short stroke, small bore, pneumatic cylinder operating in the range of 100-300 cycles/minute. It must operate 16 hrs/day, 240 days/yr. This represents many cycles of trouble-free operation. In our packaging equipment, actuation of small mechanisms at high speeds is most important. I can find no better way of getting relatively high forces to the part to transfer the mass in a very short time. Therefore, speed and reliability of service are my requirements for a small pneumatic cylinder.

J. R. GOLAN
Group Leader
Soap Packaging Equipment Design
Procter & Gamble
Cincinnati, Ohio

We at Argonne National Laboratory are often restricted to radiation resistant materials throughout our designs. This includes seals in air cylinders. Good sealing, long life, metallic seals in frequently used cylinders are in demand here. The fluid we use is argon, and the pressure requirement is usually about 100 psi.

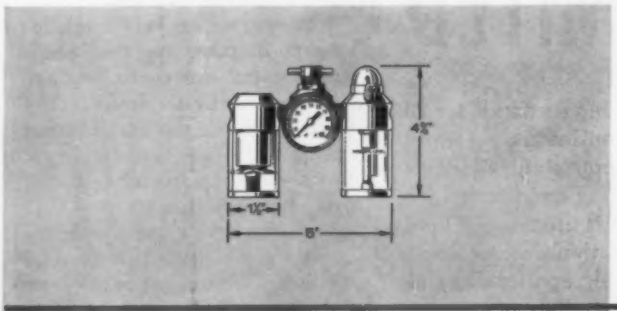
G. FIALA
Designer
Argonne National Laboratory
Argonne, Illinois

I would like to see relief valves for hydraulic fluids with miniature envelopes for aircraft usage. They should have cracking pressures to 4000 psi with zero leakage.

J. MALONEY
Components Engineer
Westinghouse Electric Corp.
Air Arm Division
Baltimore, Maryland

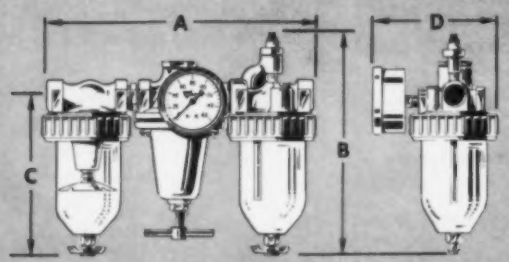
now... Modernair presents a complete range of sizes in

AIR CONTROL UNITS



MINIATURE—⅛" and ¼"

Compact assembly ideal where space or low flow requirement is a factor. Filter has 20 micron porous bronze element. Lubricator has exclusive bypass principle providing excellent lubrication at flow rates .2 to 15 cfm without excessive pressure drop. Maximum pressure 150 psi. Model M1-516G (⅛"), $22.25*; Model M2-516G (¼"), $22.25*.



DIMENSIONS AND PRICES (standard models)

Model No.	Size	Dimensions (inches)				Weight (lbs.)	Price*
		A	B	C	D		
M2-628	¼"	9⅛"	7⅜"	5⅛"	4⅝"	4	$31.00
M3-628	⅜"	9⅛"	7⅜"	5⅛"	4⅝"	4	31.00
M4-628	½"	12⅝"	8¼"	5⅜"	5⅛"	5¾	35.00
M6-628	¾"	16"	11¼"	7⅞"	6¾"	14	66.00
M8-628	1"	16¾"	11¼"	7⅞"	6¾"	14¼	66.00
M10-672**	1¼"	11"	14⅞"	11¾"	4⅞"	10	62.50
M12-672**	1½"	11"	14⅞"	11¾"	4⅞"	10	62.50

*Prices f.o.b. factory or warehouse subject prior sale.
**Filter-lubricator only (no regulator).

STANDARD—¼", ⅜", ½", ¾", 1", 1¼", 1½"

Plastic or metal bowls available for filters and lubricators. Maximum pressures are 150 psi with plastic, 250 psi with metal bowls. Filter has 40 micron porous bronze element (20 micron available at extra cost). Temperature range is −40 to 120° F with plastic bowls, −40 to 200° F with metal.

CAPACITY AND QUICK SIZING CHART
SERIES 18, 19

Size Inches	Supply Pressure	CFM AIR FLOW AT 10% DROP FROM REDUCED PRESSURE SETTING OF:							
		15	25	50	75	100	125	150	175
¼"	100	25	35	15	20				
	150	30	50	50	35	25	26		
	200					50	53	56	53
	225					55	60	68	69
	250					60	75	79	77
⅜"	100	25	40	17	25				
	150	40	55	60	60	30	30		
	200					60	73	84	82
	225					70	80	92	101
	250					80	100	104	114
½"	100	130	125	23	60				
	150	195	200	145	145	100	105		
	200					115	125	135	135
	225					125	145	155	160
	250					145	185	200	210
¾"	100	180	205	70	90				
	150	300	295	110	150	120	125		
	200					132	146	162	162
	225					150	175	180	185
	250					160	195	215	220
1"	100	200	220	110	100				
	150	320	345	125	165	125	130		
	200					140	156	177	170
	225					160	185	194	204
	250					180	200	229	240
Red. Press. Range		1-25	3-50	10-125			50-175		

EXAMPLE: What size regulator must be used to deliver 125 CFM air at 50 PSI from a supply pressure of 150 PSI? Under the "50" column and opposite a "150" it is found that the ½" size will deliver 145 CFM.

Why not get all the facts on Modernair's complete line of air products for industry? Call your local Modernair dealer (see your phone book yellow pages) or write us now for your copy of Modernair's 1961 full-line catalog.

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Meeting engineering demands for 20 years has meant continual upgrading for the Greer Accumulator. Today's reliability, safety and service are the result of this unmatched field and operational experience. Engineering application and service are available from any of the 23 field offices, distributors or factory personnel. Bring your engineering problem on standard accumulators or special adaptations to Greer.

Friction Free Bladder Types
3000 psi, 8 sizes: 10 gal., 5 gal., 2½ gal., 1 gal., 1 qt., 1 pt., 10 cu. in., 1½ cu in. 6000 psi, 3 sizes: 10 gal., 5 gal., and 2½ gal. The only type of its design approved under ASME codes of unfired pressure vessels. Approved by Coast Guard and I. C. C. regulatory bodies. Meets J. I. C. regulations.

Floating Piston Types
3000 psi, 14 sizes: 30 gal., 25 gal., 20 gal., 15 gal., 12 gal., 10 gal., 5 gal., 4 gal., 2½ gal., and 1 gal.; 116 cu. in., 60 cu. in., 30 cu. in., and 10 cu. in.

Spherical Types
1000-3000 psi, 3 sizes: 10", 7" and 5" diameters

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FORUM

Most of the pneumatic cylinders we purchase are used to operate slide gates of various types. These gates are all used in conjunction with our conveyor systems.

However, we are very much interested in other types of pneumatic controls for controlling our vibrating material feeder. The feeder employs a pneumatic spring system which uses pressure regulators, valves, transmitters, etc. for controlling purposes.

We were having some problems finding components that could withstand the rugged service we required, and yet retain stability and quick response. We have been able to solve most of these problems, and we are on the right track to solving the rest of them.

HYDRAULICS & PNEUMATICS has been very helpful to us in the past, and we feel certain it will continue to be so in the future.

JOHN V. DIEHL
Controls Engineer
Carrier Division
Chain Belt Company
Louisville, Ky.

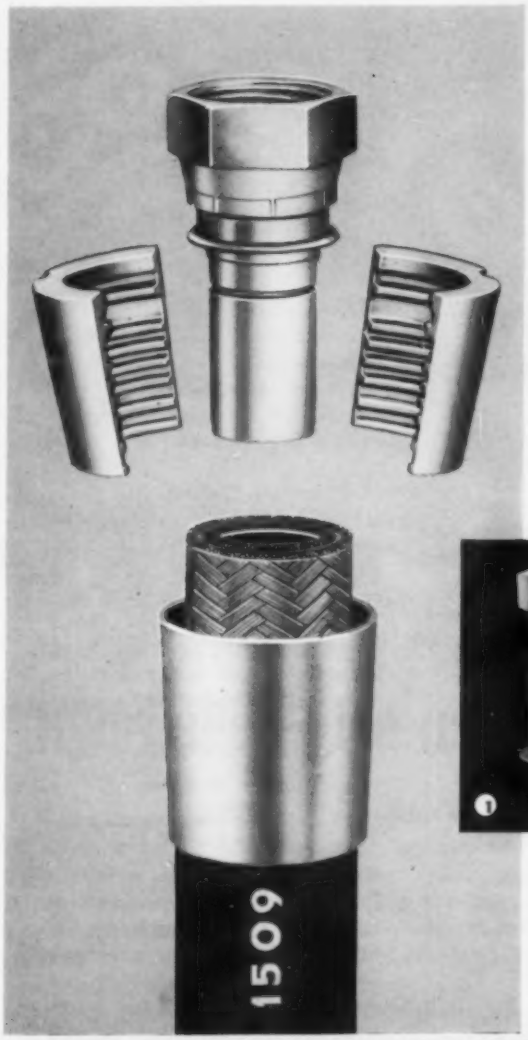
We need higher speed, quieter operation, smaller stock sizes (1000-3000 psi), low priced hydraulic motors. The market would be much broader for consumer type products. Also a 1-hp, single-phase, 1000 psi to 3000 psi, *low speed* rotary pump unit costing around $100 would make a lot of small consumer and service industry equipment feasible. For example, powering hand hydraulic presses, cut-off tools, clamps, and other labor savers for small industry and service companies. We know this is completely practical if produced in volume.

M. G. DUNDEE
President
Practical Products Corp.
Tulsa, Oklahoma

I need a pair of cylinders connected in parallel with built-in flow equalizers for closer control of positioning and timing.

D. CROSS
Development Engineer
Fairfield Engineering Co.
Marion, Ohio

NEW IRON MIKE T.M.

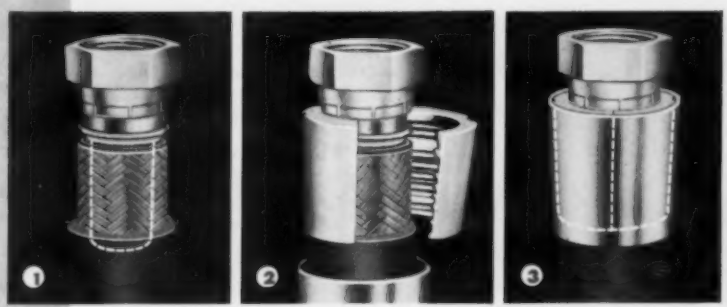


REUSABILITY PLUS LOW COST MAKE IT THE MOST IMPORTANT NEW HIGH PRESSURE HOSE FITTING IN YEARS

Aeroquip scores a major breakthrough in the cost of high pressure hose lines. IRON MIKE Fittings are completely reusable! IRON MIKE Fittings are exceptionally low cost! They give you the design, prototype, manufacturing and field service advantages provided by hose lines with standard reusable fittings . . . at the low cost of hose lines with non-reusable fittings.

Use IRON MIKE Fittings with Aeroquip Multiple Wire Braid Hose for hydraulic systems up to 2250 psi. as well as for pneumatic, fuel and lubrication lines. IRON MIKE Fittings are available with 10 standard end styles for hose sizes from ¾" to 2" I.D.

Field tested and thoroughly dependable, IRON MIKE Fittings feature quick, easy, foolproof assembly. Get complete information by returning the coupon below.



IRON MIKE Fittings consist of a steel nipple, two aluminum segments, and a tapered steel socket. Assembly of IRON MIKE Fittings and 1509 Hose is simple and sure: **1.** Rubber Cover is stripped from hose end and threadless nipple is inserted into hose. **2.** Two segments mate with nipple assembly to assure correct positioning. **3.** Tapered socket is forced over segments to form a rugged compression fitting.

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Aeroquip Corporation, Jackson, Michigan

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EQUIPMENT BUILT BY AMF'S UNION MACHINERY DIVISION USES THESE VICKERS COMPONENTS

CUSTOM POWER PACKAGE—A double-ended 60 hp electric drive motor is the prime mover for the two main hydraulic drives—one powering the developer (30 to 50 hp), the other driving the incorporator (5 to 10 hp). Vickers also supplies auxiliary control valving as part of the complete package. For more details on customized or standard power packages contact your Vickers application engineer.

PISTON PUMPS—AMF's application employs variable-displacement pumps having electrical remote volume control. Industry's broadest standard line includes models with flows to 180 gpm and pressures to 5000 psi, plus a wide variety of controls. For additional information write today for Bulletins 61-81, 61-84 and Catalog 5001C.

HYDRAULIC MOTORS—This fixed-displacement motor is only one of a complete line that includes models for variable horsepower (constant torque) or constant horsepower (variable torque) output characteristics in ratings from fractional to hundreds of hp.

Vickers adjustable-speed hydrostatic drives offer many unique advantages and economies—especially for applications where there are problems of space, weight, fast acceleration, infinite speed or tension control, sudden braking or reversing, hazardous or corrosive surroundings.

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FORUM

Pressure ratings of 2000 psi for gear pumps to 6000 psi for piston pumps and a limited number of 10,000-psi pumps appears adequate for present requirements. However, the selection of equivalent high pressure, fluid motors is limited.

Lastly, the component manufacturer would provide a valuable service if certified performance data were given to design engineers. This would facilitate the evaluation and selection of a unit to obtain the best application and design of the system.

D. WALTMAN
Chief Project Engineer
Henry Spen and Company, Inc.
Brooklyn, New York

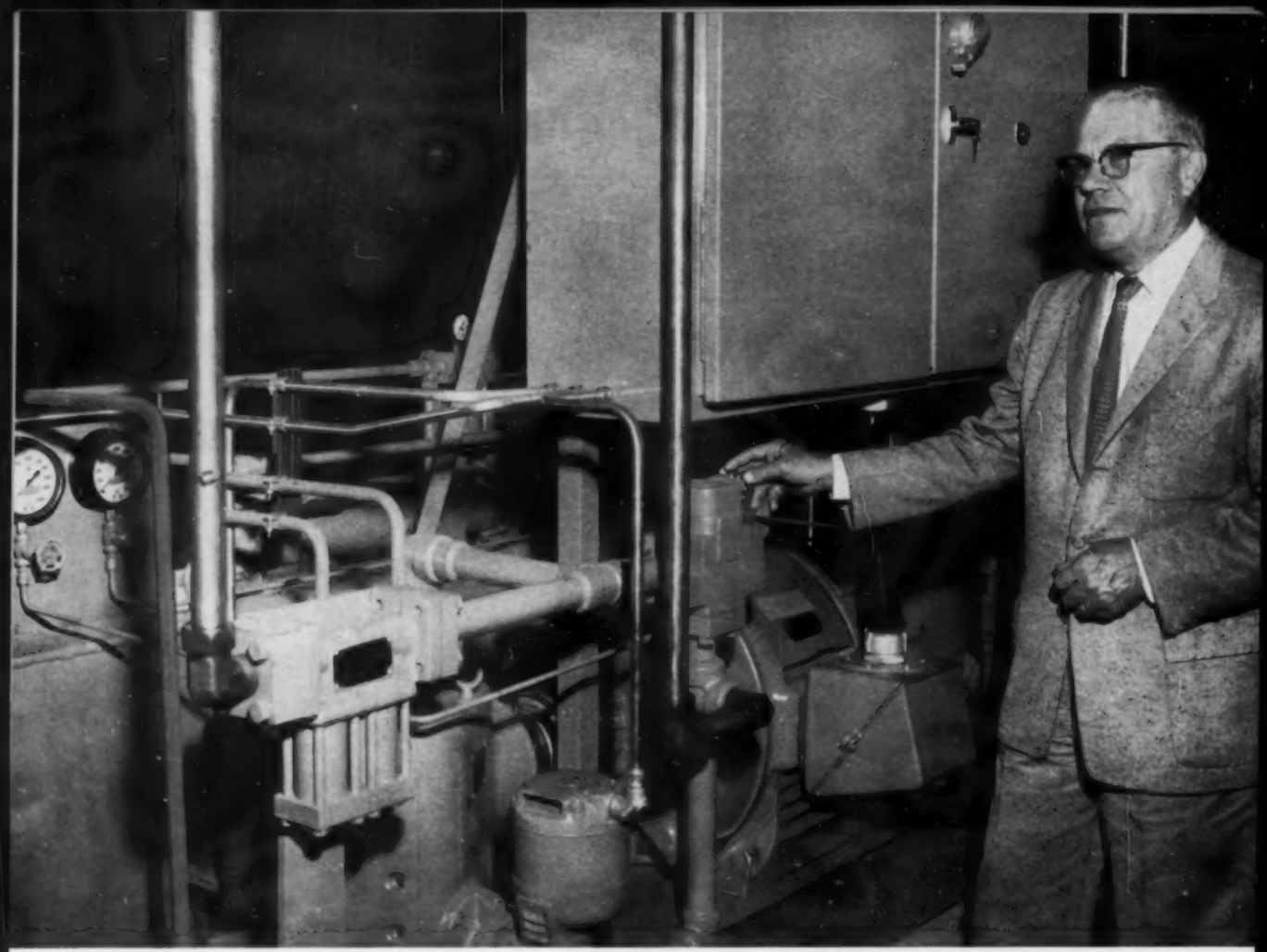
The present trend in hydraulic cylinders appears to be away from cylinders with cast heads towards those with block steel heads. However, in all cases, the length of cushion is considerably less in the block steel head than in the cast head. Longer cushions are available in the block steel heads, but involve special and sometimes questionable designs and in all cases, extra costs.

Since one of the reasons offered for turning to the block steel head is its lower cost, where does the extra cost of duplicating the cushion characteristics of the earlier type cylinder leave the purchaser?

L. C. SCHROEDER
Designer
Wilputte Coke Oven Div.
New York, N. Y.

We would be interested in valves and controls with pressure capability to 10,000 psi for laboratory use. In particular, there does not seem to be any small gauge valves with this pressure capability and provision for quick shut-off. Such valves should also be reasonably priced. On some test set-ups we used several such valves connected to gauges and to switch lines and gauges.

RALPH WALLACE
Research Engineer
International Harvester Co.
Manufacturing Research Div.
Chicago, Illinois ▼▼▼



MELBURN B. HANCOCK, CHIEF ENGINEER, AMF'S UNION MACHINERY DIV., SAYS:

"Hydraulics give us compactness, easy clean-up..."

". . . accurate speed control, and freedom from noise and vibration in the operating area. Because the use of adjustable speed hydrostatic transmissions on bread machinery was, in a sense, a pioneering effort, we found it essential and helpful to work closely with Vickers engineers in developing a completely workable system that offered our customers advantages unobtainable elsewhere.

"Our speed control must be accurate since any speed variation may degrade the end product. This speed control is required from about one-half speed to maximum speed of the equipment. Also, the system must be extremely flexible since operating speeds vary from time to time depending on characteristics of the raw material.

"With hydraulics we are able to reduce the overall size of the equipment for the production area where space is at a premium. Combined with other space saving design features, this machine is smaller than would otherwise be possible.

"Last . . . but by no means least in the food industry . . . is the ease with which the machine can be cleaned (firehoses are usually used to wash down equipment) because hydraulic units are sealed from external moisture, etc. This is a daily operation on breadmaking machinery and is a major advantage to commercial bakeries."

Whether your requirement is for a refinement to existing methods of applying hydraulics or a completely new approach to providing power and control to machinery, Vickers design and application engineers are ready to work with you to effect the most efficient and economical solution. See facing page for more details about components and systems used by Union Machinery Division, American Machine & Foundry Co., and the overall Vickers line.

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40% longer hose life

INCORPORATE SURGEPRUF'S BIG DESIGN ADVANTAGES INTO YOUR HYDRAULIC EQUIPMENT!

Research proves non-skive hydraulic hose assemblies last 40% longer than skived assemblies. That means 40% less replacement cost! Here's why: the wire braid in Surgepruf's hydraulic hose is buried in rubber... stays buried in rubber. The result: a "super-seal" that literally fuses rubber to metal—prevents leaks.

Surgepruf's rugged hose meets SAE Hydraulic Standards' dimension, working pressure, and burst requirements—has wide temperature range—resists weather aging, abrasion, water, and oil. It's available in IDs from $\frac{3}{16}$" to 2".

Using Shur-Lock reusable couplings, these non-skive assemblies provide fastest on-the-job replacement. No special assembly tools are required.

IMPORTANT: Surgepruf's full line of interchangeable hose, reusable couplings, and adapters are always available from Alemite's many sales outlets coast-to-coast. Get full information and detailed specifications today... send for free Surgepruf catalog No. 40-25, today!

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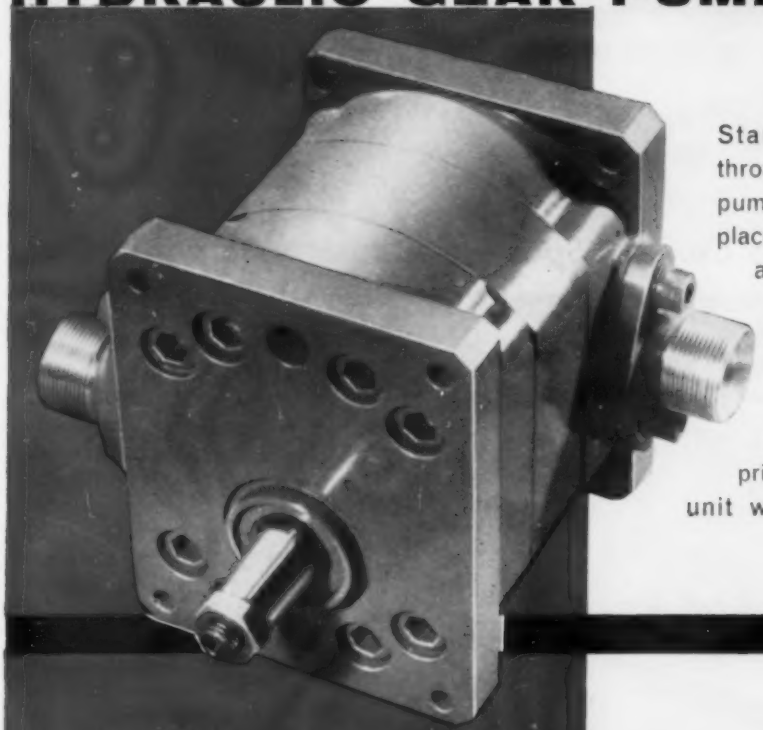
KEELAVITE
Hydraulics

HYDRAULIC GEAR PUMPS [G. P. SERIES]



Standardization is achieved throughout the range of GP gear pumps. This range covers displacements of from 4 to 33 g.p.m. at pressures up to 3000 p.s.i. Keelavite GP pumps have been simplified to use only the minimum number of parts. This meets the demand for a simple, low priced, high performance pump unit which is extremely reliable.

Two basic body sizes are currently available. By the use of standard cover plates and stock gears and gear housings, nine different units are obtainable. These nine are, in turn, easily adaptable to one of three shaft arrangements — front, rear or double shaft, clockwise or anti-clockwise operation.

TYPE	Maximum Continuous Pressure	G.P.M. at 1000 r.p.m.	Cu. In. per Rev.	Maximum Speed
GP.2004A	2,000 p.s.i.	4.3	1.19	3,000 r.p.m.
GP.2005A	2,000 p.s.i.	5.8	1.63	3,000 r.p.m.
GP.1707A	1,700 p.s.i.	7.3	2.02	3,000 r.p.m.
GP.1209A	1,250 p.s.i.	9.4	2.6	3,000 r.p.m.
GP.3011	3,000 p.s.i.	11	3.0	2,000 r.p.m.
GP.2011	2,000 p.s.i.	11	3.0	2,000 r.p.m.
GP.2017	2,000 p.s.i.	17	4.6	2,000 r.p.m.
GP.1522	1,500 p.s.i.	22	6.1	2,000 r.p.m.
GP.1033	1,000 p.s.i.	33	9.1	2,000 r.p.m.

For full details write to

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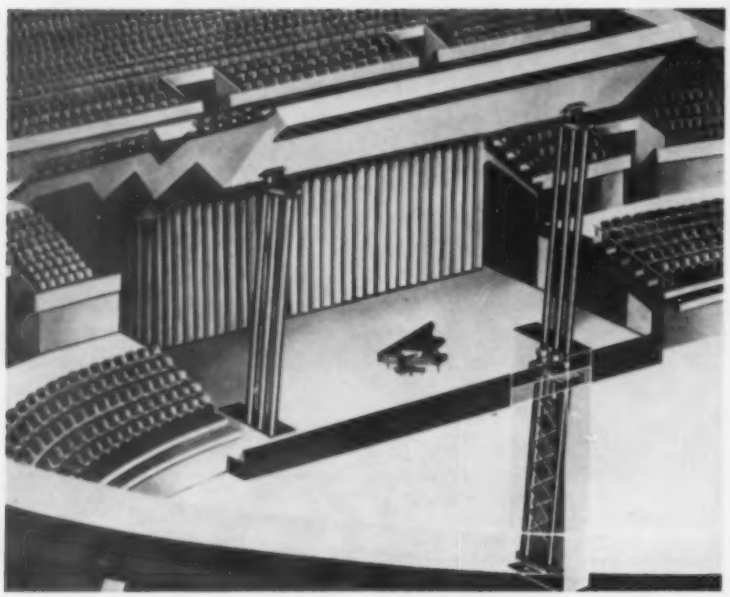
FLUID POWER AT WORK

keeping up with design, application, methods

Hydraulic Cylinders to Convert Sports Arena Into Amphitheater



Four hydraulic cylinders—two on each side—will lift and lower a giant canopy seat section in Pittsburgh's new all-weather Public Auditorium, and convert it to an arena or an amphitheatre to suit the event. Two additional cylinders—one on each side of the section—will act as locking posts to hold the canopy section up.

The six cylinders are each more than one foot in diameter, and will raise the 2100-seat, 220-ton section through a 36½-foot stroke, and lock it. A cable equalizing system will keep the trunnion mounted cylinders level with respect to one another while they extend or retract. System pressure will be 1000 psi. The cylinders were manufactured by the Rotary Lift Co., a division of the Dover Corp., Memphis, Tenn. ▼▼▼

International Standards and the U. S.

"Our markets—both domestic and international—especially the markets being created in underdeveloped countries will be directly affected by our participation in international standards. To keep these potential markets open for our products, we must become more standards-minded and actively participate in the work of these international organizations to make sure that our point of view is well represented." This was the expression of O. J. Maha, president of Parker-Hannifin Corp. in a recent report to the National Fluid Power Society, an association of hydraulic and pneumatic component manufacturers.

Businessmen from a group of European countries (Belgium, France, Germany, Great Britain, Holland, Sweden, and Switzerland) interested in the standardization of fluid power have formed the European Technical Commission of Hydraulic Transmissions. This group is working as a committee to submit standards in the field of fluid power to the International Standards Organization (ISO) for adoption on an international basis. The president of this commission is Mr. Victor Pomper of France.

At a session of the Commission held last February at Wiesbaden, West Germany, a new set of international standards for hydraulic symbols was accepted unanimously and is now under consideration by the ISO at Geneva. The ISO has indicated that they have minor reservations, but it is not anticipated that there will be any major alterations to the symbols.

Suggestions for amendments to the symbols can be submitted during the next two years. The Swiss delegation, originators of the symbol document, have also submitted a preliminary draft for a trilingual translation of terminology. This

Continued on page 32

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Air and Hydraulic

CONTROL VALVES

Whatever the application . . . whatever the service . . . whatever the pressure range . . . whatever the size . . . whatever the actuation required . . . chances are you'll find a valve in the Hunt line *exactly* suited to your needs.

Sizes range from ⅛ through 8 in. for vacuum to 300 psi air and for water, soluble oil and water, or oil to 5000 psi.

Your nearby Hunt representative will be pleased to work with you. You'll find him listed in Sweet's Product Design File.

HUNT

QUICK-AS-WINK© AIR AND HYDRAULIC

VALVES

HUNT VALVE COMPANY • DIVISION OF IBEC • SALEM, OHIO

For more information, write for Bulletin 603. Address Dept. AH-861, Hunt Valve Company, Salem, Ohio.

3001

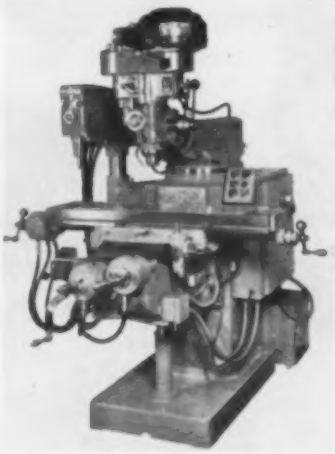
will be circulated to all member nations.

• **Membership**—At the London meeting of the commission in May, 1961, it was agreed that any country able to claim a professional national organization can apply for membership.

The National Fluid Power Association is negotiating with Dr. William Schlosser, who represents Holland on the Commission, to investigate participation in international standards.

Duplicator Traces Profiles

A hydraulic tracer control adds fully automatic, 3-dimensional scanning and profiling to milling machines manufactured by the Tree Tool and Die Works, Racine, Wis. Following the contour of the model, the stylus operates a dual valve, which coordinates knee-and-table or knee-and-saddle motions. As either the table or saddle



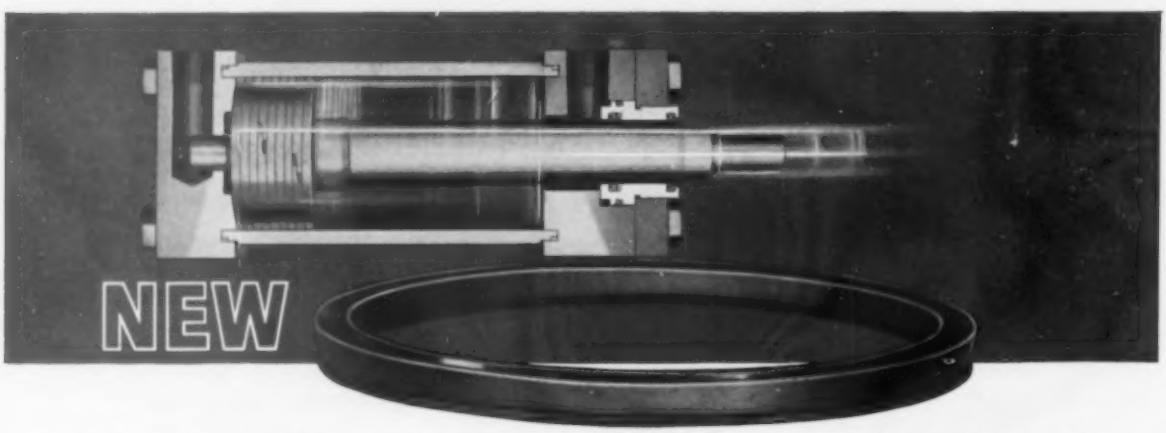
moves to scan the model, a constant rate of cutter speed is maintained over any surface from vertical to horizontal. The machine operates automatically for close tolerance duplication, or semi-automatically for profiling. Constant torque hydraulic motors drive the lead screw of the mill, thus retaining the original ruggedness for heavy milling. ▼▼▼

Hydraulic Wrenches for Railroad Tracks

Hydraulic wrenches tighten or remove all bolts at rail joints in one operation, on this railroad track maintenance machine manufactured by Railway Maintenance Corp., Pittsburgh. The battery of six wrenches is driven by hydraulic motors which can be operated together or individually from a master control panel. One man controls all operations.

After the hydraulically propelled machine is spotted over a joint, hydraulic cylinders position the heads in place. The fluid motors then tighten the bolts. The machine develops sufficient torque to remove frozen nuts, or twist off the bolts if necessary. ▼▼▼

DURATON ROD SEAL IN HYDRO-LINE CYLINDERS



Here is a new opportunity to reduce machine downtime and costs caused by cylinder leakage or scoring: Hydro-Line's "Duraton" rod seal — exclusive durability formed from Fluorel®, guarded by backup washer of carbon-impregnated Teflon.

Leakproof seal is assured by superior resistance of "Duraton" rod seal-backup washer combination to abrasives, corrosives, and pressure. Retains effective resiliency at temperatures to 400°F and higher. Compatible with virtually all hydraulic fluids. Resists aging.

Iron-oxide-colored "Duraton" rod seals, Ebalon backup washers, and Fluorel wipers are standard on Hydro-Line Series N2 hydraulic cylinders to 5000 psi. See your Hydro-Line representative for details.

HYDRO-LINE

® Registered trademark of Minnesota Mining & Mfg. Co.

5601 PIKE ROAD, ROCKFORD, ILLINOIS, manufacturers of: high- and low-pressure hydraulic cylinders • heavy-duty air cylinders • boosters • adjustable-stroke cylinders • dispensing cylinders • single-acting cylinders • rod end couplers

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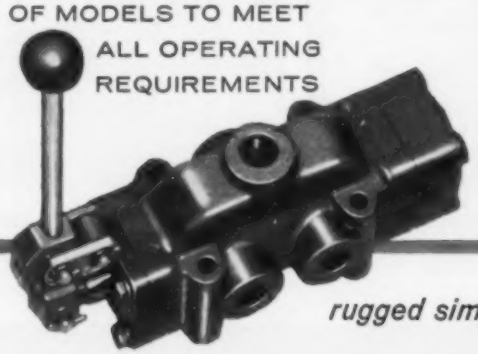
ADEL...offers you *single source* responsibility

for precision hydraulic control valves

4-WAY SELECTOR VALVES IN A VARIETY OF MODELS TO MEET ALL OPERATING REQUIREMENTS



a complete line for every application

GENERAL SPECIFICATIONS

FLUID: Oil, for hydraulic use only.
PRESSURE: 1500 psi maximum.
FLOW: 3 to 28 gpm.
PORT SIZES: ¼ to 1" pipe size.
MATERIAL: Slides and spools—hardened steel; bodies—gray iron castings.
Various forms of return springs or detents for slide positioning.

MODELS

Lever-Operated For Hand Control. Stem-Operated For Remote Manual Control.

Solenoid-Operated in Various DC and AC Voltages.

Pilot-Operated For Remote Hydraulic Control.

rugged simplicity for efficient, long, reliable service life

These compact, 4-way selector valves are used for control of double acting, or single acting cylinders. Simple spool-type construction provides a wide variety of porting arrangements for either open-center or closed-center hydraulic systems.

The Valves With Maximum Operating Efficiency Over The Years
***Let ADEL be your* single-source *for* precision hydraulic equipment**
Write for valve brochure containing complete specifications.

Designers & Manufacturers of Industrial & Marine Hydraulic Control Equipment

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A DIVISION OF GENERAL METALS CORPORATION

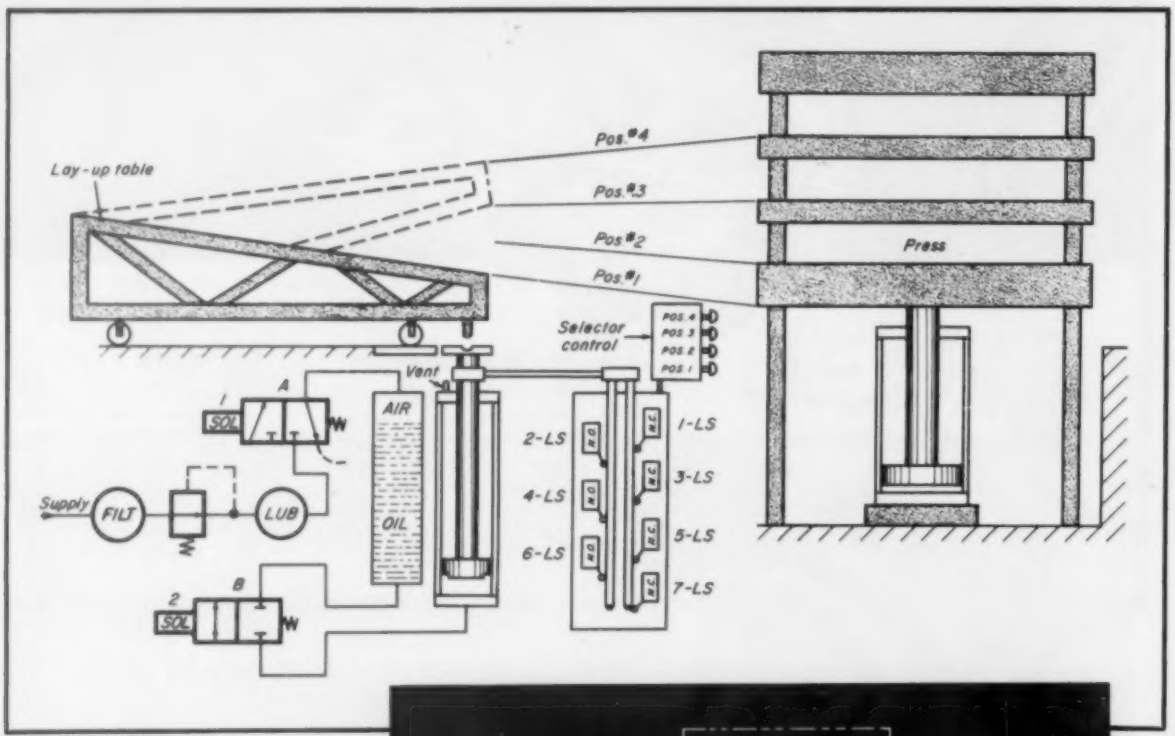
FLUID POWER AT WORK

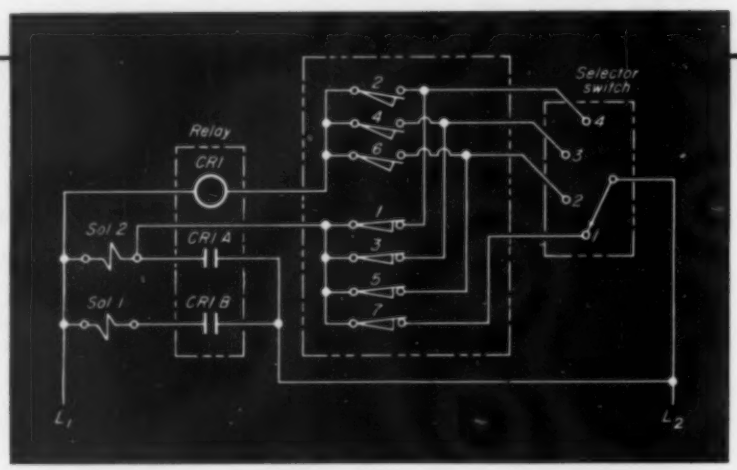
Indexing cylinder helps feed presses

Making wooden veneer table tops requires rapid handling so that the glue will not set before the veneer plies are placed in the forming press and cured.

Workers at Artistic Veneers, Chicago, use a linear positioner made by Hanna Engineering to raise and lower the lay-up table from which veneer sandwiches are fed into the press. An air-over-oil system raises the lay-up table and aligns it with each opening in the press. Two workers then slide the veneer sandwich into the press, and index the positioner to the next opening.

Two long cams are fastened to the piston rod. When the switch for positions 2, 3, or 4 is closed, solenoids *A* and *B* are energized,





MOTION of hydraulic cylinder is controlled by actuating limit switch rollers along cams' path. Electrical circuit shows how limit switches are connected to solenoids to energize proper indexing station.

and the cylinder extends. Limit switches along the cams' path are connected in pairs (one NO and one NC) for each position. In each pair of limit switches, the rollers are staggered, so the cam stops in the null band between a NC limit switch actuated to its open position and a NO switch which remains open. The electrical circuit is then broken, solenoids *A* and *B* are de-energized, and the cylinder stops. This process is repeated for each successive indexing position of the cylinder.

After the third layer of veneer is unloaded at position 4, the switch for position 1 is closed.

LINEAR positioner is shown in fully extended position. Lay-up table is visible in left background.

Solenoid *B* is energized, while solenoid *A* remains de-energized, allowing air to exhaust out of the top of the reservoir. The weight of the lay-up table returns the single acting cylinder to its retracted position as oil is pushed back into the reservoir through valve *B*.

▼▼▼

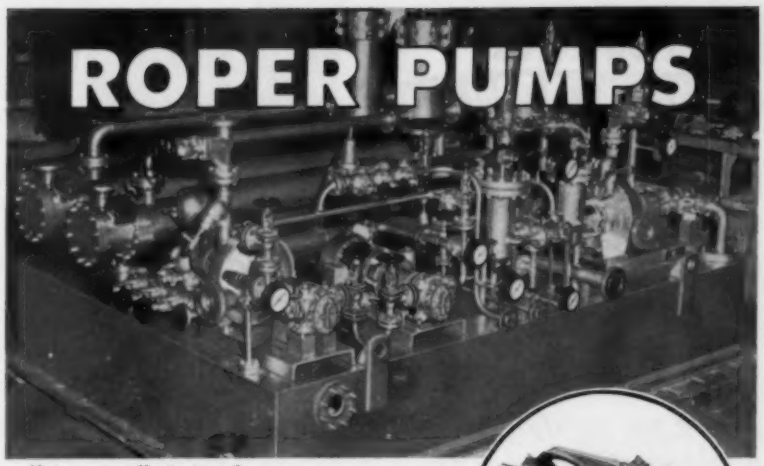


Photo courtesy The Engineer Co.

maintain lubrication of seals and oil bearings on large centrifugal compressor

• CAPACITY RANGE: 5-75 GPM • OPERATING PRESSURES: TO 1000 PSI

The complex lube system for this centrifugal compressor was designed by The Engineer Co. for the Elliott Co. and Blaw-Knox for Ashland Oil Co., using two types of Roper pumps as booster and main lube units. The Fig. 1H15 booster pumps handle 70 SSU viscosity SAE-10 lube oil at operating temperatures of 140°F, and deliver up to 17 gpm at 475 psi pressure. The two main lube pumps are specially modified Roper Series K units handling 76 gpm at 50 psi. Close cooperation with The Engineer Co. by Roper determined the pumps which would best serve the needs of this lubricating system. Special problems involving pump components for your equipment will receive this same skilled assistance by Roper engineers.

RELIABLE SERVICE AT HIGH PRESSURE

- **SPUR GEARS,** specially designed for high volume efficiency at high pressures, are hardened, ground, shaved, and perfectly balanced to operate quietly, smoothly.
- **DRIVE SHAFT,** separate from the drive gear, protects pumping gears from thrust load stress, preserving the axial hydraulic and mechanical balance of the gears.
- **ROLLER BEARINGS** and bronze wearplates are built for heavy-duty use, absorbing stress of heavy loads and continuous service. These parts are lubricated and cooled by liquid being pumped, and are easily, quickly replaced.

Contact your nearest Roper Dealer for specific pump information

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CYLINDERS • BOOSTERS
SERIES A

Standard Cylinders
AIR or OIL
Without Modification
Save money with S-P's complete line; rated 200 psi air, 500 psi oil or water; 23 mounting types; 11 bore sizes—1½" thru 14"; see Catalog 110C.
SERIES B

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Hydraulic Cylinders
Get smoother, more precise power; ruggedly built, interchangeable; 2000 psi (3000 psi non-shock); 12 bore sizes—1⅛" thru 12"; get Catalog 117.
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FLUID POWER AT WORK

Design with Pressure Drop Ratings

Optimum hydraulic system design can only be achieved when the designer has complete data on the performance of all components making up the circuit. This holds true across-the-board—for pumps, motors, valves, cylinders, etc. With control valves, complete pressure drop information is prerequisite to correct application. Increasing emphasis, therefore, is now being placed on an informed approach to the rating and application of valves.

Past practices involved confusing rule-of-thumb techniques. Valves were selected without full knowledge of their performance. Although the designer had the necessary data to determine pressure drop through a line of certain length and diameter, there was no information on valve pressure drop. It had to be assumed that valves available to fit the line size would have the proper pressure drop for the flow rate involved. This "blind" approach restricted the designer in the selection of valves for optimum performance.

In the past, there has been a wide variation in the recommended flow capacity of valves in relation to pressure drop. In some cases, this variation even existed between the valves marketed by one manufacturer. As valve design evolved, corresponding changes took place in pressure drop acceptablility. Various influences made it impractical for the valve manufacturer to adhere to any one level of rating. As a result, there was no uniformity of pressure drop characteristics between valves made by different manufacturers.

Today, the designer or user takes a more critical approach in selecting and applying valves. He wants to know exactly what pressure will be required to put a given amount of fluid through the unit. For this reason, the terminology used in expressing valve ratings must be clear and complete. It is not enough to say a valve is rated at "10 gpm at 15 psi pressure drop." In this case the 15 psi value is meaningless, because it fails to define the specific flow path through the valve and the fluid conditions involved.

Even more pointless is the statement "10 gpm at 15 ft/sec velocity." To avoid such ambiguity it is necessary to provide information on flow paths, effects of different spool configurations, and effects of variations in flow rate and viscosity.

• **New Rating Method**—A new and simple rating method which meets these requirements has been introduced by Vickers Inc. Complete pressure drop information is now included on newly released engineering installation drawings. This consists of a pressure drop chart and additional notes pertaining to the effects of changes in flow rate, viscosity, and specific gravity. The tables show those portions of a typical installation drawing where this information is presented.

They include figures representing pressure drop in psi through the flow paths shown on the normal JIC symbol. These figures are based on the nominal flow capacity of the valve with a 100 SSU fluid whose specific gravity is about 0.865. For other flow rates, the pressure drop varies directly with the square of the flow (approximate). A formula is given for ease of computation.

For viscosities other than 100 SSU, there is a corresponding change in pressure drop. This information is also given. Pressure drop for various viscosities is based on a percentage of "nominal" pressure drop. This chart replaces a cumbersome formula.

VALVE PRESSURE DROP ΔP FOR NOMINAL CONDITIONS

P to A	B to T	P to B	A to T	P to T
18	34	18	30	25
20	38	20	35	
20	34	20	30	
18	34	18	30	
20	38	20	35	

Approximate pressure drops (ΔP) when passing the nominal 8 gpm flow of 100 SSU fluid having 0.865 specific gravity.

For any other flow rate (Q_1), the pressure drop (ΔP_1) will be approximately:

$$\Delta P_1 = \Delta P \left[\frac{Q_1}{Q}\right]^2$$

VALVE PRESSURE DROP CORRECTION FOR VARIOUS VISCOSITIES

For SSU	% of ΔP
75	90
200	111
250	126
300	132
350	137
400	141

For any other specific gravity (G_1), the pressure drop (ΔP_1) will be approximately:

$$\Delta P_1 = \Delta P \left[\frac{G_1}{G}\right]$$

For specific gravities other than 0.865 for oil, there is a corresponding change in pressure drop. Fire-resistant fluids generally have higher specific gravity values. The change in pressure drop is about directly proportional to the change in specific gravity. A formula is given to accommodate this.

• **Flow Limits**—In addition to pressure drop data new installation drawings list nominal and maximum flow attainable without malfunction. This maximum rating is not based on pressure drop, but on the fact that a valve can be safely crowded up to the point where the spool may not shift properly.

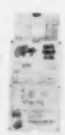
A broad spread is allowed between nominal and maximum ratings, giving a wide latitude in the valve's application. By making use of the pressure drop information supplied, the designer will be assured of optimum service. ▼▼▼

PARCO PROBLEM PROBERS

Consistent O-Ring Quality

The quality and dependability of any pressurized hydraulic or pneumatic control or operating system hinges largely on the leak-proof properties of the seals used to segregate pressure differentials within the system. In many systems, molded rubber "O" Rings are used for this purpose. These "O" Rings must provide a dead-tight seal at all times regardless of operating temperature within the specification range. They must be totally resistant to system fluids or gases and must maintain physical constants throughout their operational life. ○ For many years Parco has been one of the nation's major producers of "O" Rings which meet these varied and rigid requirements. With these two requirements met, resistance to system fluids or gases —resistance to temperature variations, and maintenance of physical constants automatically follows. ○ These features add up to the consistent high quality and leak-proof properties which have made Parco "O" Rings a synonym for failure-free operation.

Send for your latest Parco Slide Rule



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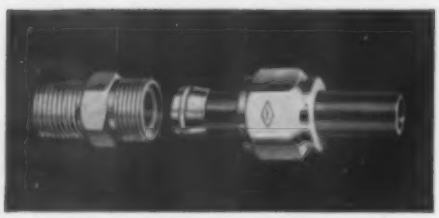

to meet more pressure, temperature, shock, vibration conditions than does any other tube fitting

. . . in more styles, sizes, combinations and materials than any other fitting. For more information, see next page . . . and write for Catalog 3108.

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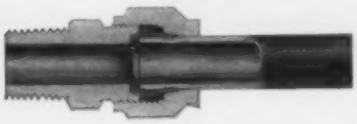
one

tube fitting— versatile Hi-Seal®

With Hi-Seal you can overcome moderate to toughest service conditions—in one entire system or in several. With simple variations in the basic fitting, you meet al-



most every need—just specify a change in type of metal and vary the sleeve and nut. Thus, you match Hi-Seal to pressure, temperature, vibration, shock and installation variables.

50 TYPES—1300 SIZES

Hi-Seal Fittings are available in straight connectors, straight reducers, unions, adapters, elbows, tees, crosses, caps, couplings, swivel nuts, valves, port seal and Braze-Seal. Altogether there are almost 50 types—collectively more than 1300 sizes, generally from 1/16" tube O.D. to 1½". Metals available include steel, stainless steel, brass, aluminum, titanium, Monel and others. Combinations are almost endless!

Now Imperial-Eastman meets all your requirements for hydraulic-pneumatic-flow system components: tube fittings, valves, couplings, flexible and rigid hydraulic and pneumatic lines, thermoplastic tubing, tubing tools.

See Imperial-Eastman first!

FITTINGS

IMPERIAL-EASTMAN

FLUID POWER AT WORK

Hydrostatic Transmission Seminar Planned

MILWAUKEE—A seminar on Hydrostatic Transmissions sponsored by the Milwaukee School of Engineering will be held on September 27th.

The first session will be an introduction to the subject of hydrostatic transmissions. The second will deal with design and analysis aspects; the third with typical and practical applications. A panel discussion on the subject will be the final activity of the day.

Registration is from 8:00 to 9:00 A.M. the morning of the seminar. Sessions will be held at the school's Bradley Hall of Science, 432 E. Kilbourn Ave. Advanced registration $20 per person—$25 at-the-door. This fee will include luncheon. Further information is available from Melvin E. Striegel.

The Milwaukee Chapter of the Fluid Power Society is planning a dinner meeting following the seminar. Mr. Frank Flick will speak on "Cylinder Design and Application Concepts." Here, the only charge will be for the dinner.

▼▼▼

BRIEF NOTES

PAMPHLET ON SEALS . . . A four-page brochure on seals has been published by General Motors Corp. The booklet discusses the causes of lip seal leakage, principles of good sealing, and a lip seal testing machine.

NEW FILTER FIRM ORGANIZED . . . The Wallace Filters, Inc., was recently organized in Lebanon, Ind. The company will design, manufacture, distribute, and sell industrial filters.

BRONZE FOUNDRY INCREASES OUTPUT . . . A new bronze foundry with a melting capacity of 12,000 lbs per day was put in operation by the Darling Valve Co., at Williamsport, Pa. The new plant nearly doubles the daily capacity of the old foundry.

LITERATURE ON NEW NYLON SHAPES . . . A four-page bulletin describing MC nylon is available from the Polymer Corp., Reading, Pa. The brochure lists physical property data, suggested applications, and complete mill shapes.

REDUCING VALVES FOR POLARIS FIRING SUBS . . . A follow-on order for production of high-pressure reducing valves for nine Polaris firing submarines was awarded to the AiResearch Div. of the Garrett Corp., Los Angeles.

RADIATOR PIONEER HONORED . . . Fred M. Young, president and founder of Young Radiator Co., Racine, Wisconsin was one of five engineers and industrialists recently honored by Wisconsin engineers. He was cited for his oustanding accomplishments.

LITERATURE ON TEFLON PRODUCTS . . . Chem Flow Corp., Little Falls, N. J., announces a new six-page booklet on Teflon products including Teflon covered steel adapters.

TEFLON FOR CORROSIVE, HIGH TEMPERATURE VALVES . . . By using Teflon parts, the Rockwood Springler Co., Worcester, Mass., has extended the use of its ball valves to handle corrosive chemicals or gases, and fluids at extreme temperatures.

PLASTICS REFERENCE BOOK . . . Pocket-size, 12-page reference book has valuable conversion information and data for plastics men and application engineers. Available from Commercial Plastics & Supply Co., N. Y.

HYDRO-JECTOR

AUTOMATICALLY DRAINS ANY FILTER, DRAIN LEG OR SURGE TANK

- GUARANTEED minimum 1 year trouble-free operation
- ½" internal discharge port
- Connecting Nipple available in 3 sizes
- Discharges at rate greater than 300 gallons of water per hour at 125 PSI
- Drains oil as well as water
- Transparent *Visi-Bowl* permits visual inspection
- Operates on pulsating, continuous or no flow
- No air loss during dump cycle
- Vent Nipple prevents air lock
- Manual Plunger permits "clean-out" without disassembly

The *M/P Hydro-Jector* can be installed easily and quickly in the bottom drain port of *any* compressed air filter, separator, drain leg, water bottle, surge tank, air receiver tank or other water collecting vessel.

This is not an ordinary float operated trap. The *Hydro-Jector* incorporates unique pilot valving and large internal discharge passages.

Only M/P offers a one year guarantee against clogging.

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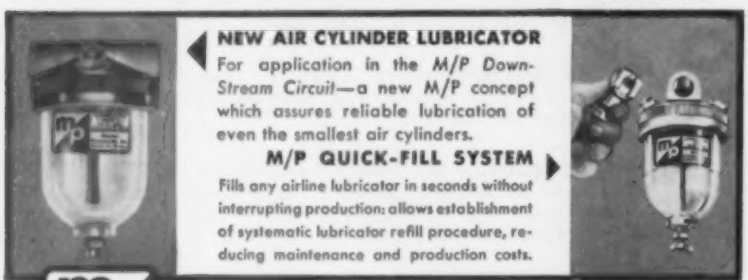

NEW AIR CYLINDER LUBRICATOR
For application in the *M/P Down-Stream Circuit*—a new M/P concept which assures reliable lubrication of even the smallest air cylinders.

M/P QUICK-FILL SYSTEM
Fills any airline lubricator in seconds without interrupting production; allows establishment of systematic lubricator refill procedure, reducing maintenance and production costs.

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FUTURE EVENTS

ASTM MEETING ON AEROSPACE HYDRAULIC FLUIDS

Aerospace Applications for Hydraulic Fluids & Test Methods, Technical Committee N, Committee D-2

August 2-4

SantaYnez Inn
Pacific Palisades, Calif.

For further information, contact M. L. Fickel, c/o Maledco Engineering Corp., 731 West Wilson Ave., Glendale 3, Calif.

1961 CRYOGENIC ENGINEERING CONFERENCE

August 15-17

Univ. of Michigan
Ann Arbor

SAE PRODUCTION FORUM & ENGINEERING DISPLAY

Combined SAE Farm, Construction, and Industrial Machinery; Power Plant; and Transportation Meetings.

September 11-14

Milwaukee Auditorium

HYDROSTATIC TRANSMISSION SEMINAR

September 27

Milwaukee School of Engineering
(See page 39 for further information)

SAE A-6 COMMITTEE MEETING

Aerospace Hydraulic & Pneumatic Systems & Equipment.

Week of September 25

Ramada Inn
Phoenix

SAE AEROSPACE ENGINEERING & MANUFACTURING MEETING

October 9-13

The Ambassador
Los Angeles

FLUID POWER SOCIETY ANNUAL MEETING

October 18

Sherman Hotel
Chicago

NATIONAL CONFERENCE ON INDUSTRIAL HYDRAULICS

October 19-20

Sherman Hotel
Chicago

NFPA FALL MEETING

October 24-26

Sheraton Hotel
Philadelphia

Circle 99 →

One-inch body diameter
valve line

Completely new series of **SKINNER** solenoid valves
facilitates further miniaturization

Here's a really miniature stainless steel solenoid valve with all the features of a larger valve

think small

VALVE SHOWN ACTUAL SIZE

- Now designers of pneumatic and hydraulic control systems and devices requiring high flow in smaller packages can **specify miniature solenoid valves from shelf stock.**
- These new B Series valves are so small and so new that ⅛" NPT was too large, therefore 1/16" PTF connections were selected. Fittings are included to make fluid connections with ⅛" tubing.
- Never before have there been valves like this—**really miniature in over-all size, pipe size, and weight.**

VITAL STATISTICS

Type	3-way normally closed
Over-all size	1" x 2⅛"
Orifice size	3/64" Inlet and Outlet
C_v factor	.045
Fluid connections	1/16" PTF (adapted for ⅛" tubing)
Weight	5 oz.
Maximum operating pressure	150 PSI
Vacuum	Down to 5 microns

Skinner Distributors are now stocking the first of these new valves—the three-way normally closed. Three-way normally open and directional control, two-way normally open and normally closed, and higher pressure models will be on the market soon.

For complete information contact a Skinner Distributor listed in the Yellow Pages or write us at the address below.

B SERIES FEATURES

No leakage—Soft, synthetic inserts provide bubbletight sealing. Seats have smooth rounded edges—no cutting of insert material.

Mounting by means of two tapped mounting holes (8-32) in valve body. Can be mounted in any position.

Voltage—Coils available in most AC and DC voltages. Heat rise meets U.L. standard of 85°C maximum for continuous duty. Maximum power requirement—7 watts.

Electrical housings are available with single grommet or ¼" NPT conduit which can be rotated 360°.

Media—B Series valves may be used with all common media including many semi-corrosive fluids.

Corrosion-resistant—Stainless steel body and internal parts.

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THE CREST OF QUALITY

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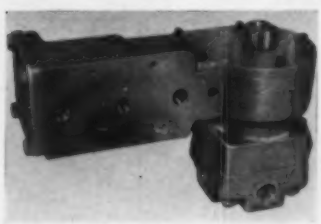
NEW PRODUCTS

Circle the numbers on the Reader Service post card for more information

VALVE ACTUATOR

Shop air or hydraulic pressure (100 to 125 psi) operates Lo-torq Valve Actuator for 6000-psi valve. A minimum of 70 psi is required. Maximum working pressure: 500 psi. The actuator is nose-mounted to the valve, making a compact,



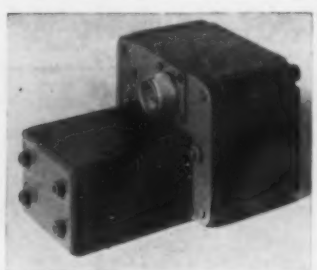
efficient arrangement. Cylinder is 3-position, operating 45 degrees each side of center, in any combination of 45 and 90 degree movements.

Specifications: Actuators may be mounted at factory or in the field to Lo-torq "B" valves up to 1" size having 90 degree turn.—*Republic Mfg. Co., Cleveland*

Circle **300** on Reader Service Card

SINGLE-STAGE SERVOVALVE

Provides flow output proportional to electrical input. Torque motor armature and valve spool are only



moving parts. When used with standard filtration, spool valve and high force torque motor provide shearing action for maximum reliability. Special technicians not needed for maintenance.

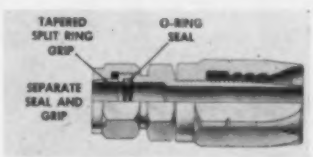
Specifications: Pressures from 200 to 1000 psi. Flow rating 3 gpm, 350-psi pressure drop. Temperatures to 170 F. Sub-plate or gasket mounting. Recommended 10-micron, full-flow filter. Weight 8 lbs.

Designation: Series SC4.—*Vickers Inc., Div. of Sperry Rand Corp., Detroit.*

Circle **301** on Reader Service Card

TUBE-TO-HOSE FITTING

The Tube End Hose Fitting permits joining of tube directly to a hose without the use of an adapter. The tube-end incorporates the "O-Ring Seal" fitting with separate grip and seal. This fitting eliminates the need for a female swivel



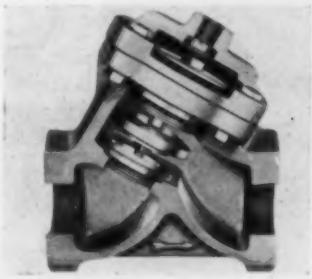
or threading, flaring, or soldering of tubes or pipes. The tube need not be cut straight or to exact length.

Specifications: Fittings are available for double wire braid hose (Series 216), or single wire braid hose (Series 116). The full line ranges in hose size from 3/16" to 1¼" ID with tube OD from ¼" to 1¼".—*Lenz Co., Dayton, Ohio*

Circle **302** on Reader Service Card

DIAPHRAGM VALVE

Features a diaphragm actuator, working directly off actual line pressure. Diaphragm is neoprene reinforced with nylon. Line pressure applied above diagram, forces diaphragm, stem, and disc down to close valve on seat. When this pressure is removed, disc line pressure pushes diaphragm to wide-open position. Open air vent for lower chamber between diaphragm and barrier plate permits



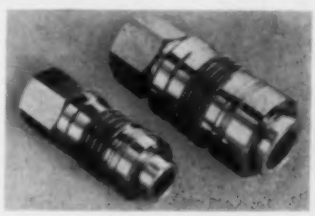
easy operation of diaphragm when operating valve.

Specifications: Series 431 in ¾" and 1" sizes. Series 424, 1¼" and 1½". Series 426, 2" and 2½". Screw-type with cast iron bodies. Hot dip galvanized in sizes under 1½".—*Aquamatic, Inc., Rockford, Ill.*

Circle **303** on Reader Service Card

PNEUMATIC COUPLING

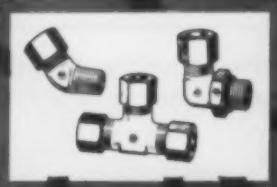
The Dyna-Con is a coupling and a valve that is designed for any application where automatic couplings are used. Air-flow design with no conventional valve components to restrict flow gives high

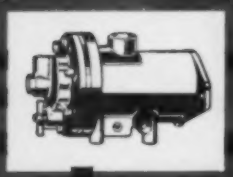


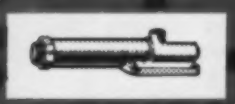
capacity. No line pressure or valve spring resistance to overcome during coupling.—*Dyna-Quip, div. of Stile-Craft Mfgrs. Inc., St. Louis.*

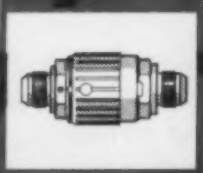
Circle **304** on Reader Service Card

WEATHERHEAD FLUID POWER PRODUCTS . . . SYSTEM ENGINEERED









WEATHERHEAD ERMETO

"THE ONLY FITTING WE'VE FOUND THAT ELIMINATES TROUBLE"

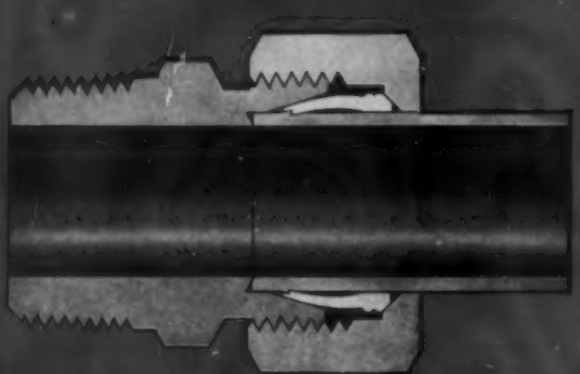
This is typical of reports from users of these self-sealing, high-pressure flareless connectors. Reasons: ease of assembly and disassembly; no special tooling required; avoids threading and flaring while providing positive seal; reusable—maintaining no-leak, stress-free support of tubing after multiple make and breaks.

Weatherhead Ermeto fittings are engineered to withstand severe vibration, shock, pulsating loads, temperature extremes, and pressures to 15,000 psi.

For your fluid system reliability, specify Weatherhead Ermeto.

A complete range from ¼" to 2" is available from your nearby Weatherhead distributor.

THE WEATHERHEAD COMPANY
CLEVELAND 8, OHIO

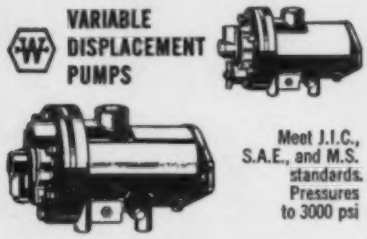


ERMETO®
"Hermetically sealed"

Circle 114 on Reader Service Card

WEATHERHEAD
HYDRAULIC POWER
Components

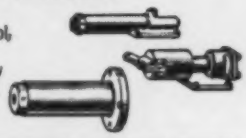
VARIABLE DISPLACEMENT PUMPS



Meet J.I.C., S.A.E., and M.S. standards. Pressures to 3000 psi

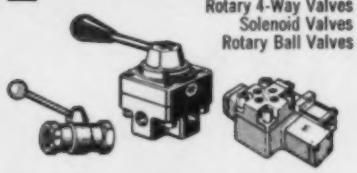
PUMP CONTROLS

Pressure Control, Automatic (Constant) Flow Control, Manual Displacement Control



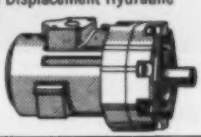
DIRECTIONAL CONTROLS

Rotary 4-Way Valves
Solenoid Valves
Rotary Ball Valves



HYDRAULIC DRIVES

Fixed Displacement Hydraulic Motors, Reversible Variable Displacement Hydraulic Motors (Integrated Torque and Speed Control)



HIGH PRESSURE HOSE AND FITTINGS

Swaged, Crimped, and Field-Attachable Flexible Hose Ends.
Flared and Flareless Tube (Pipe) Fittings.
Integral Check Valves

SELF-SEALING COUPLINGS

Ball Check Valve Type
Full-Flow Rotary Ball Type

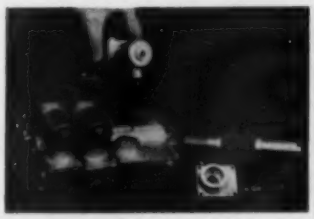
THE WEATHERHEAD CO.
300 EAST 131 ST. • CLEVELAND 8, OHIO
Distributors in all major markets

Circle **115** on Reader Service Card

NEW PRODUCTS

STACKING MANIFOLD AIR VALVES

Single and double solenoid models. Two or three position, three or four way. Valve can be lifted from manifold plate and easily replaced



by removing four bolts. Valve solenoids plug into electrical connections in manifold plate.

Specifications: Sizes ¼", ⅜", and modified ⅛".—*Beckett-Harcum Co., Wilmington, Ohio.*

Circle **305** on Reader Service Card

HEAVY-DUTY TANK TRAPPER

A heavy duty mounting for the *Tank-Trapper* has a support rod made from ⅝" cold rolled steel—standard rod is ¾" black iron pipe.

The magnetic units are used for removing ferrous contaminants from hydraulic fluid reservoirs. The new mounting is for use where a long support rod is required.—*Kebby Co., Rockford, Ill.*

Circle **306** on Reader Service Card

FLOW-REGULATING VALVE

Extremely fine adjustment in low flow range. Internal design permits

flow equal to full pipe area in both directions. Knife-edge variable orifice within valve reduces flow distortion caused by viscosity changes in medium.

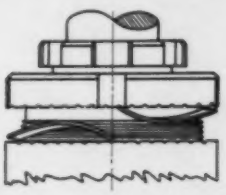
Specifications: Flow increases from zero to 10% of potential during first 360-deg rotation of valve adjusting sleeve. Successive rotations produce flow volumes of 30%, 65%, and 100%. In ⅛", ¼", ⅜", and ½" pipe sizes. Temperatures from −40 F to 250 F. Air pressure to 250 psi, oil to 1000 psi.

Designation: Dyna-Trol.—*Mead Specialties Co., Chicago.*

Circle **307** on Reader Service Card

CYLINDER HEAD LOCKING

Locking device holds threaded heads on cylinders. Knurling on both end of cylinder tube and inner edge of cylinder head holds a split wavy washer. Cylinder head will

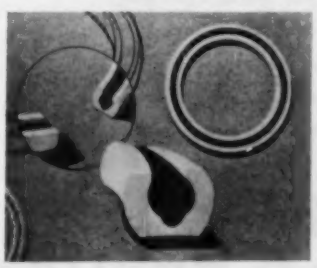


then screw on with spring acting like a ratchet. Removal of head requires spring deformation.—*Universal Hydraulics, Willoughby, Ohio.*

Circle **308** on Reader Service Card

ROD & PISTON SEAL

The Tec-Ring rod and piston seal uses an internal expander in its



Teflon ring to overcome that material's lack of resilience. The expander maintains a continuous force against the sealing surface, overcoming Teflon's tendency to shrink away from those surfaces when temperatures are reduced. Expanders are stainless steel or synthetic rubber—depending on use.

Specifications: Rings need no adjustment; range in size from ⅛" to 15" ID.—*Tanner Engineering Co., Los Angeles.*

Circle **309** on Reader Service Card

Smooth output at lowest shaft speeds...

NEW WEBSTER HYDRAULIC MOTOR WITH INTEGRAL GEAR REDUCER

SPECIFICATIONS:

Models: S, with a torque range from 39 to 142 inch pounds per 100 psi.
Input flow: Gpm at 1000 psi —
2.2 to 5.8 at 100 rpm output speed
4.9 to 15.5 at 300 rpm output speed
7.5 to 25.1 at 500 rpm output speed
Gear reduction: 4.65 to 1
Operating pressure: up to 2000 psi standard
Pumping gears: smooth-running spur involute — precision hobbed from alloy steel
Motor drive: free-floating internal spline
Seal: mechanical face-type on drive shaft
Porting: 1" NPT inlet and outlet standard, 1¼" "O" ring straight thread optional. ¼" NPT drain port.
Mounting: SAE-type "D" four-bolt mounting standard
Drive: Direct, gear or belt
Weight: 48 to 51 lbs.

This new Webster gear-type fluid motor combined with a planetary gear reducer was designed for high torque, low speed operations. High reduction ratio (4.65:1) assures smooth output at lowest shaft speeds!

The unit is extremely compact and provides stable, constant speed operation under varying loads. When used with a variable output flow divider, it becomes the high torque output element of an infinitely variable transmission. It is ideal for indexing, turning and transfer mechanisms; hydrostatic drives, winches, reels; turning or tilting units; batch mixers; driving elevators, conveyors — even earth augers.

The Webster motor-gear reducer has other important advantages: it may be used where it is impossible to use an electric motor because of explosion hazards... planetary gear assembly is lubricated by the hydraulic system..."straight through" drive between input and output shaft... mounts on an SAE standard, 4-bolt D size hydraulic pump mount. Drive is direct, gear or belt.

Your Webster Electric representative can tell you more about this interesting new hydraulic motor with integral gear reducer — or write direct for engineering detail sheet HY6-1.

OIL HYDRAULICS DIVISION

WEBSTER ELECTRIC

RACINE · WIS

Franklin adv. H129

NEW PRODUCTS

JOURNAL BUSHINGS

These self-lubricating, plain journal bearings are capable of dynamic loads to 25,000 psi and static yield loads to 50,000 psi at

low rotational speed. Housings are stainless steel; bushings have a Dyflon plastic alloy insert.
Specifications: Bore sizes from ¼" to 3".—*Southwest Products Co., Monrovia, Calif.*

Circle **310** on Reader Service Card

AUTOMATIC AIR LUBRICATOR

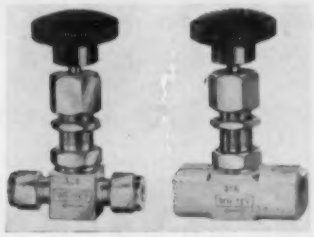
Uses unique venturi feed. Delivers lubricant to downstream line in form of suspended oily mist. Air enters plastic oil reservoir through center tube, equalizing pressures in oil chamber and air line. Oily mist is automatically injected into air

stream and controlled by pressure differential created by air velocity through the venturi. Oil filler valve permits refilling oil reservoir without shutting off air. Transparent plastic oil reservoir for visual inspection.
Specifications: Pipe sizes ¼", ⅜", ½", and ¾" NPT
Designation: PSC.—*Perfecting Service Co., Charlotte, N. C.*

Circle **311** on Reader Service Card

SCREWED BONNET VALVES

Screwed bonnet, bar stock valves (#2 Series) for ⅜" and ½" tube or



pipe are available in type 316 stainless or Monel. They are recommended for instrumentation or any application where leaktight on-off control is essential. Units can be ordered with Swagelok tube fitting connections, or female pipe thread connections on straight and angle pattern styles.—*Whitey Research Tool Co., Oakland, Calif.*

Circle **312** on Reader Service Card

POPPET VALVES

Featuring full ¼" flow, these 2 and 3-way poppet valves have fingertip, ball cam, palm button, and toggle action. Replacement of cartridge-type insert renews valve

Continued on next page

MOLDED SEALS

Complete Stocks

Dependable Engineering Service

LINEAR SEALS
"O" Rings
"V" Rings
"U" Cups
Piston Cups
Valve Packings
Diaphragms
Bonded Parts
Gaskets
Wiper Rings

ELASTOMERS
Natural Rubber
Buna-N Buna-S
Neoprene Viton
Butyl Vyram
Silicone
Polyurethane
Polyacrylic
Hypalon
Thiokol

Specially designed seals for critical applications

Buckeye Rubber & Packing Co.

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Circle **17** on Reader Service Card

← Circle **116**

NEW PRODUCTS

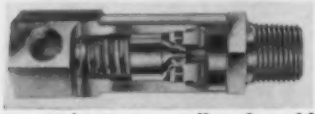
without removal from line. Valve has a compact, aluminum bar-stock

body.—*Superior Controls Div., Crystal Lake, Ill.*

Circle **313** on Reader Service Card

RELIEF VALVE

The Kep-O-Seal relief valve incorporates a combination metal and resilient seal seating that provides high performance with simple de-



sign. Valve is internally adjustable through a wide range, has excellent flow characteristics, and is quiet.

Specification: Standard units are made of steel, equipped with Teflon seals, and stocked in 10 connection combinations of ¼", ⅜", and ½" dryseal pipe. All models rated 10 gpm with relieving pressure settings up to 2000 psi.—*Kepner Products Co., Summit, Ill.*

Circle **314** on Reader Service Card

AIR PRESSURE REGULATOR

Type 20AS precision pressure regulator is for air gaging, lab use, precision pilot air regulation, and applications where accuracy and high sensitivity is required. It provides accurate pressure control up to the maximum air flow recommended for ¼" pipe. Regulation is highly accurate because the pilot valve

movement is extremely small. The use of primary air for control gives fast response.

Specifications: Regulator reduces line pressures of 0 to 150 psig to secondary pressures of 0 to 60 psig. Temperature range is 32 F to 160 F.—*C. A. Norgen Co., Englewood, Col.*

Circle **315** on Reader Service Card

INTEGRAL AIR PUMP AND MOTOR

A compact, high capacity Model K-5 integral air pump and motor

provides 27" Hg vacuum continuous, 15 pounds pressure and 12

Continued on page 52

BHEW

Hydraulic Cylinders

- Basic Designs
- Specific Adaptations
- Superior Quality
- Application Engineering

THIS IS BHEW'S "DUAL PILOT" CHECK VALVE. It insures positive piston rod lock in any position when the directional control valve is in neutral. You *know* the rod will not drift. This simplifies hydraulic line circuitry, eliminates separate pilot operated check valves, connections and lines.

- BHEW furnishes hydraulic cylinders with single or dual P.O.C. valves, with or without speed control.

Production parts save you money, do the job better! BHEW basic cylinders can easily be modified to fit your *specific* product applications. You benefit from production economies; you get custom-built cylinders.

Let's discuss your design and application problems —

FREE!

Write today for Hydraulic Cylinder Engineering Reference data — 78 dimensional basic designs for general-purpose and special-purpose double-acting and single-acting cylinders. SAVE TIME.

BH EW

BENTON HARBOR ENGINEERING WORKS, INC.

622 Langley Avenue St. Joseph, Michigan

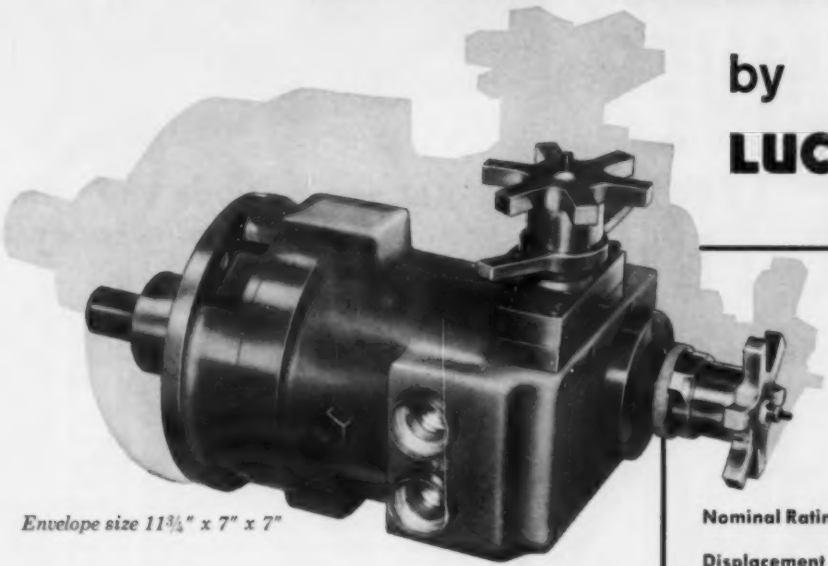
Circle **15** on Reader Service Card

Light-weight, compact and extremely versatile — the reliable

NEW IP 250 INDUSTRIAL HYDRAULIC PUMP

by

LUCAS-ROTAX



Envelope size 11¾" x 7" x 7"

PUMP DETAIL

	Basic Pump Fixed Stroke
Nominal Rating at 3,600 r.p.m.	18 G.P.M.
Displacement (cub. ins./rev.)	1.157
Working pressure up to	5000
(lbs./sq. in.) (continuous)	3000
Speed up to	4000
(r.p.m.) (continuous)	3600
Input h.p. at 1,000 r.p.m. and 1,000 lb. per sq. in. differential	3.32
Weight	29 lbs.
Operating Temperature, °F	– 40 to 200
Direction of Rotation	Either
Pressure Compensator Range	500-5000 p.s.i.

One of the complete new range of quality built hydraulic pumps and motors by Lucas-Rotax, the IP 250 offers many technical advances and advantages. **• Small size • Low weight • Variable volume • Low noise level at higher operating speeds • Low cost • High efficiency • Fitted with integral or remote pressure compensator as standard equipment.**

For further information, contact the agent or office nearest you today, or write for technical literature.

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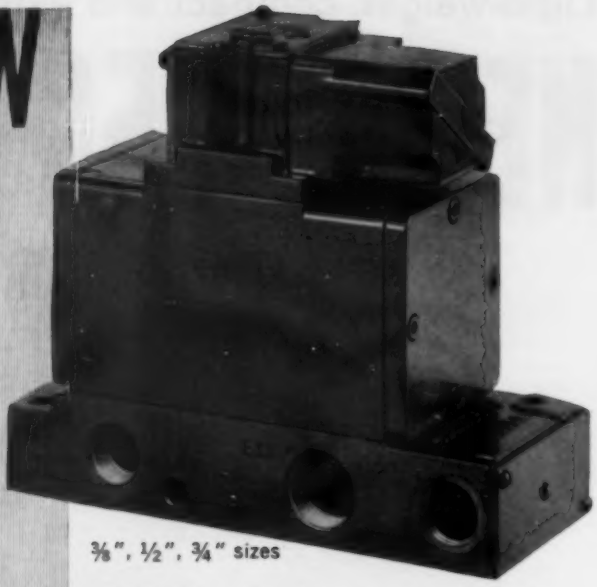
6005

NEW HANNIFIN "HUSTLER" VALVES GIVE YOU SPEED, SURENESS & GOOD SERVICE



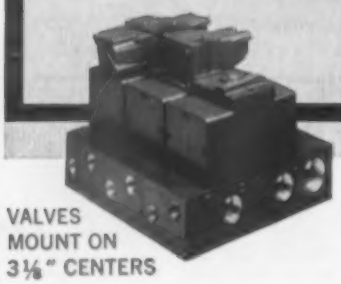
⅜", ½", ¾" sizes

ALL the features you want in 4-way, pilot-operated air control

HOW FAST? So fast it fills 12 cu. in. test chambers from 0 to 90 psi in 0.029 seconds. Larger, 100 cu. in. chambers fill in 0.075 seconds. Valve itself has been cycled on test over 3,000 times a minute. We know of no faster valve.

HOW SURE? Valve will operate on severely restricted air supplies and at pressures down to 15 psi, thanks to a reserve volume of pilot air, maintained at maximum line pressure in a self-restoring accumulator chamber (patent applied for). Low-wattage, nylon encapsulated, plug-in solenoids are guaranteed for life against burnout. New "Comb-O-Seals"—one-piece, pressure-energized—seal positively, cannot be improperly assembled. Any of today's varied air line lubricants can be used. Both pilot valve and main valves operate on poppet principle, cannot stick in dirty air.

HOW GOOD? Good for millions of leak-proof cycles! All-aluminum, die cast construction gives you light weight, assures clean, smooth air passages. Base mounting—all connections, air and electrical, are permanently made to the base. Quick plug-in feature —entire operating unit "plugs" into base; remove two screws and it lifts off easily and quickly. Locking manual over-ride is standard on all solenoid models. All models fully meet J.I.C. standards.



VALVES MOUNT ON 3⅛" CENTERS

ADD-A-FOLD BASES (optional) permit joining a number of valves together, with one supply, one exhaust, one gallery for electrical connections.

You can have either maintained or momentary contact electrical actuation—or remote pressure actuation. Valve is available in ⅜", ½" and ¾" pipe sizes. Write for new Bulletin 0611-B1.

PARKER HANNIFIN CORPORATION

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Circle 11 →

TO MAKE TWO HYDRAULIC RAMS MOVE IN UNISON

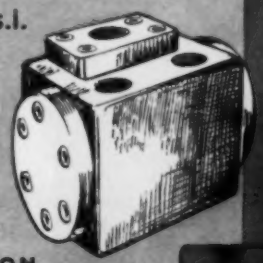
SOLUTION TO THIS PROBLEM
THE LOCKHEED FLOW DIVIDING VALVE

Maintains division of flow regardless of differing or variable loads on the actuator units.

Division of flow accurate to within 0.5% of the full rated flow of the unit.

Two sizes available—5 g.p.m. and 20 g.p.m.

Working pressures up to 3,000 p.s.i.



Full particulars of both these units on application from

LOCKHEED PRECISION PRODUCTS LIMITED
INDUSTRIAL HYDRAULICS DIVISION
SHAW ROAD, SPEKE, LIVERPOOL 24, ENGLAND
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AUTOMOTIVE
PRODUCTS GROUP

Lockheed

REGD TRADE MARK

INDUSTRIAL HYDRAULICS

NEW NYLAFLOW® PRESSURE HOSE

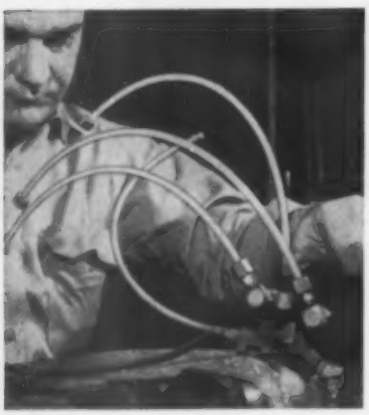
Weighs 1/5 as much...outperforms rubber hose of same burst strength

Flexible NYLAFLOW Pressure Hose* is Polymer's newest answer to jobs requiring exceptional resistance to flex and vibrational fatigue.

Available in burst pressure ratings of 5,000 up to 12,000 psi., and in long, continuous lengths and standard inside diameters up to ¼" . . . with compact, lightweight, reusable fittings or assemblies if desired.

Typical Areas Of Profitable Application:

- Hydraulic, high pressure lubrication and pneumatic lines—Unaffected by flammable and non-flammable hydraulic fluids, an excellent non-conductor.
- Freon lines—Remarkably low effusion rate for refrigeration and air conditioning applications.
- Solvent or Hot paint lines—Unaffected by almost all organic solvents.
- Anhydrous ammonia lines—Unaffected by long term exposure as proven by tests.



NYLAFLOW PRESSURE TUBING in sizes up to ⅜" O.D., and burst pressure ratings of 1000 and 2500 psi. Ideal for lower pressure requirements. Flexible for easy installation with standard flare or compression fittings.

Full details and illustrated brochures now available

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POLYPENCO

INDUSTRIAL PLASTICS

THE POLYMER CORPORATION of PENNSYLVANIA, READING, PA.

EXPORT POLYPENCO, INC., READING, PA., U.S.A.

*Patented

Circle **89** on Reader Service Card

NEW PRODUCTS

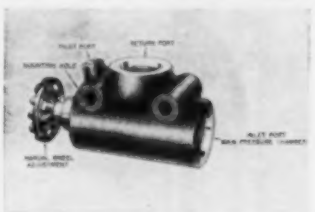
cfm. It can be run continuously, with quiet operation and no maintenance except occasional lubrication refill. The automatic oiler requires refill only once each 60 to 80 hours.

Specifications: Unit is powered by a ⅓-hp motor and measures 22⅛" long, 12" wide, and 7¼" high. *—Leiman Bros., Newark, N. J.*

Circle **316** on Reader Service Card

RELIEF VALVE

Controls line pressure by quick-response to surges. For straight relief, sequence, or bypass valves. Self-cleaning pin and hole orifice



at inlet pressure port. Pilot valve actuating pin exposed to line pressure at all times. Constant regulation of pressure.

Specifications: 30 and 80 gpm, straight or pipe thread ports.—*Fawick Corp., Cleveland.*

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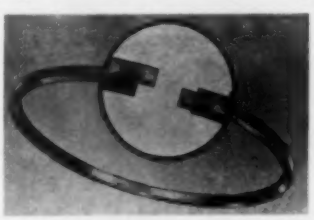
SMALL PISTON RING

This ring seals horizontally and vertically, providing a positive hydraulic seal. It permits use of fewer rings and assures sealing in both



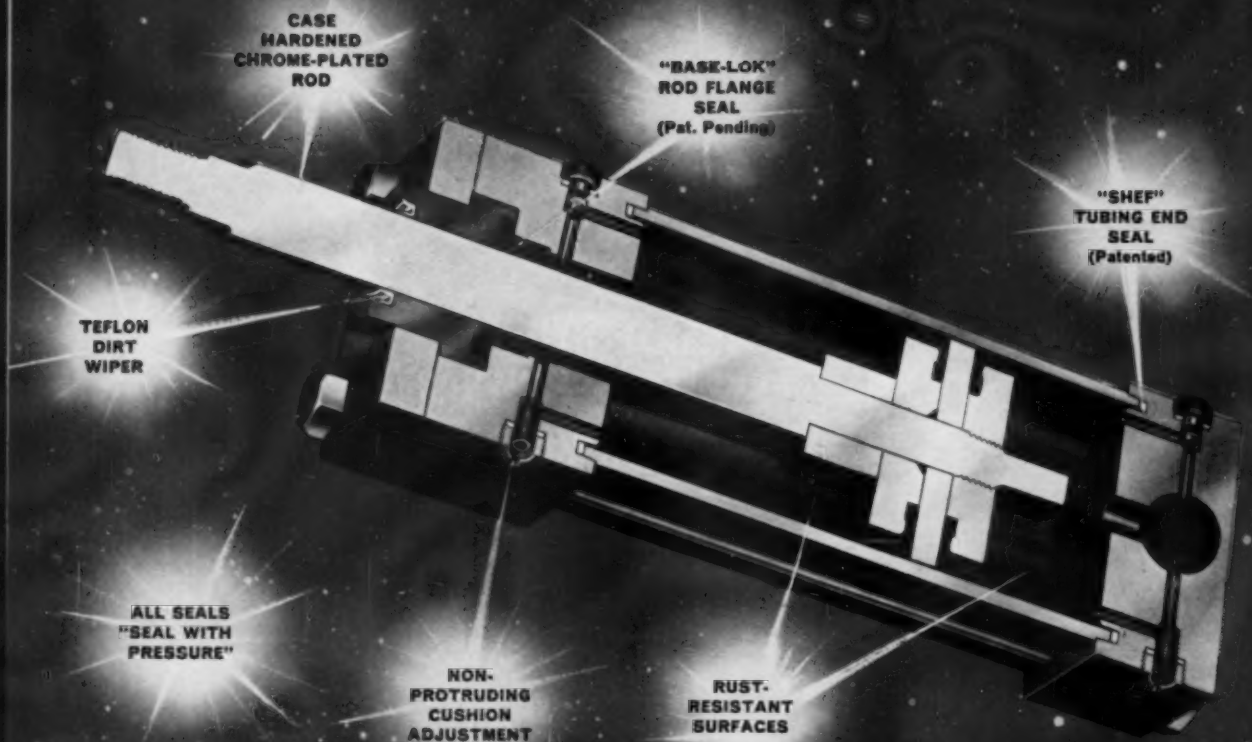
directions. Ring cannot be inserted incorrectly into the cylinder.

Specifications: 1" OD with widths through ⅜".—*Grover Piston Ring Co., Milwaukee*

Circle **318** on Reader Service Card

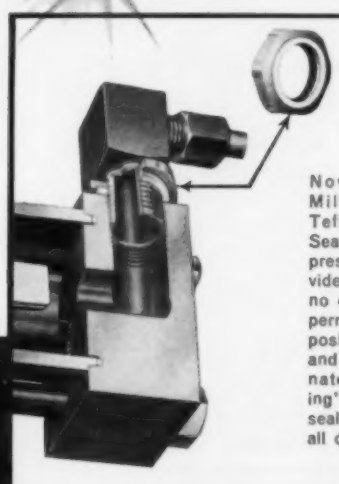
For more NEW PRODUCT reviews turn to page 118

Stellar RELIABILITY and ECONOMY


CASE HARDENED CHROME-PLATED ROD
"BASE-LOK" ROD FLANGE SEAL (Pat. Pending)
"SHEF" TUBING END SEAL (Patented)
TEFLON DIRT WIPER
ALL SEALS "SEAL WITH PRESSURE"
NON-PROTRUDING CUSHION ADJUSTMENT
RUST-RESISTANT SURFACES

Miller AIR CYLINDERS

PORT SEALS



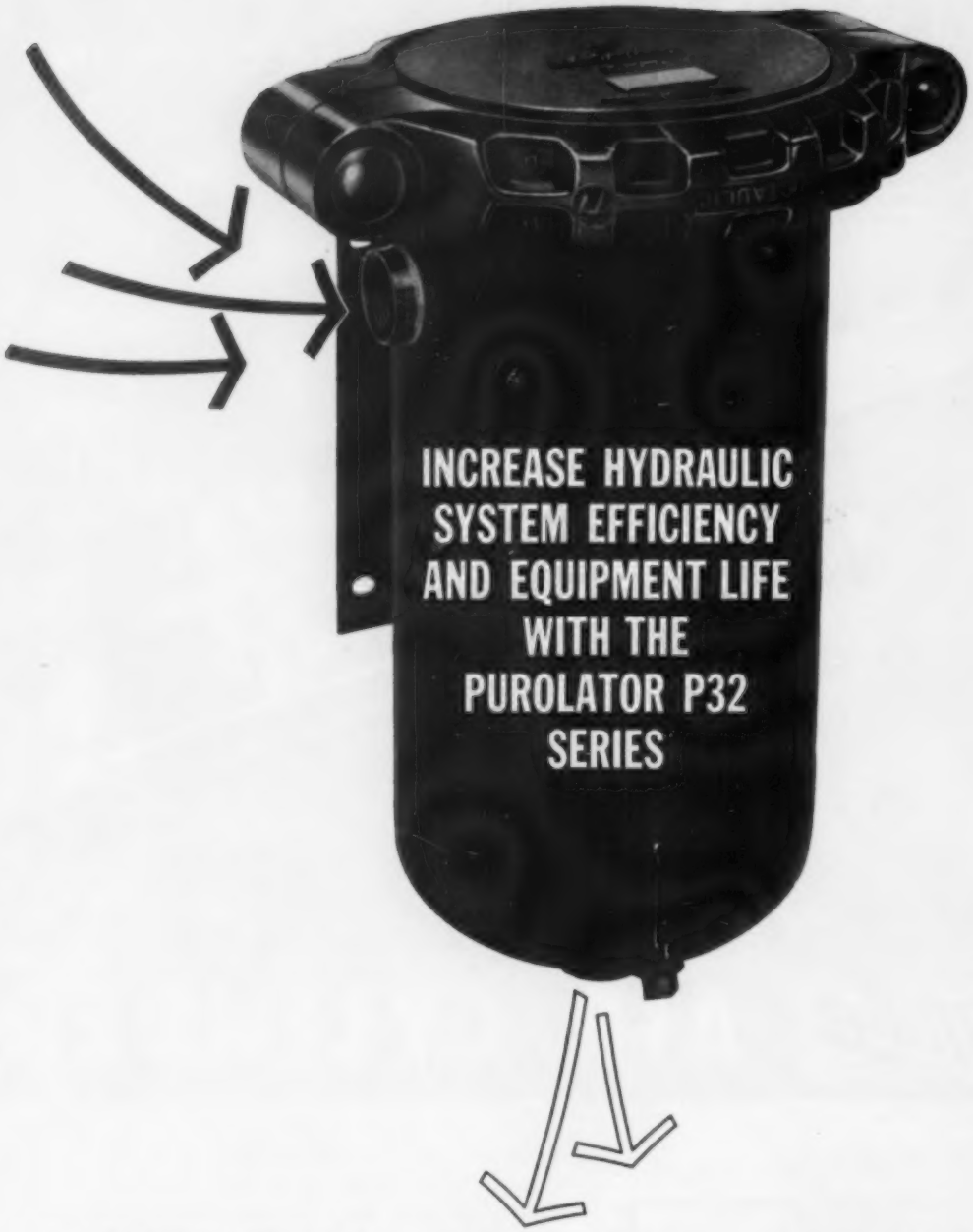
Now—with every Miller Cylinder—Teflon-sealed Port Seals that "Seal with pressure" are provided as standard at no extra cost. They permit much faster positioning of lines and fittings, eliminate "overtightening" damage, and seal perfectly against all operating media.

Here are eight more reasons why Miller Air Cylinders continue to be the most economical and reliable cylinders that money can buy. These stellar features—including the new port seals—are standard Miller construction—yours at no extra cost. Thus, they provide appreciable savings in original investment—*particularly for those who insist on "J. I. C." quality throughout.* Savings in operating costs are even greater, because these features are proven assurance of longer cylinder life, greater efficiency, reduced maintenance and downtime.

Specify "Miller" for greater reliability and economy! Write for bulletin.

MILLER FLUID POWER

7N017 York Road, Bensenville, Illinois



The Purolator P32 Micronic® Filter makes short work of hydraulic system dirt. Stops it – before it gets a chance to wreck equipment and rob you of top efficiency and output. Here's how it works:

Greater filtering area. The Micronic® Filter is a resin-impregnated cellulose element that traps contaminants, leaving vital hydraulic systems clean. It is specially preformed and pleated for maximum filtering area.

Easy element change. The clamp-lock ring construction lets you change elements without disconnecting the filter unit from the system. Just unscrew the couplings, throw away the dirty element – and slip in the replacement.

Adaptable application. You can use one or two elements, whatever you need, and install units on either the pressure or suction side of the pump. The unit can withstand operating pressure up to 300 lbs.

The P32 series is a medium size line ranging in flow capacity from 15 to 30 GPM. It is 1 of over 2000 units available from Purolator, the world's most experienced filter manufacturer. For information, write: Purolator Products, Inc., Rahway. New Jersey.

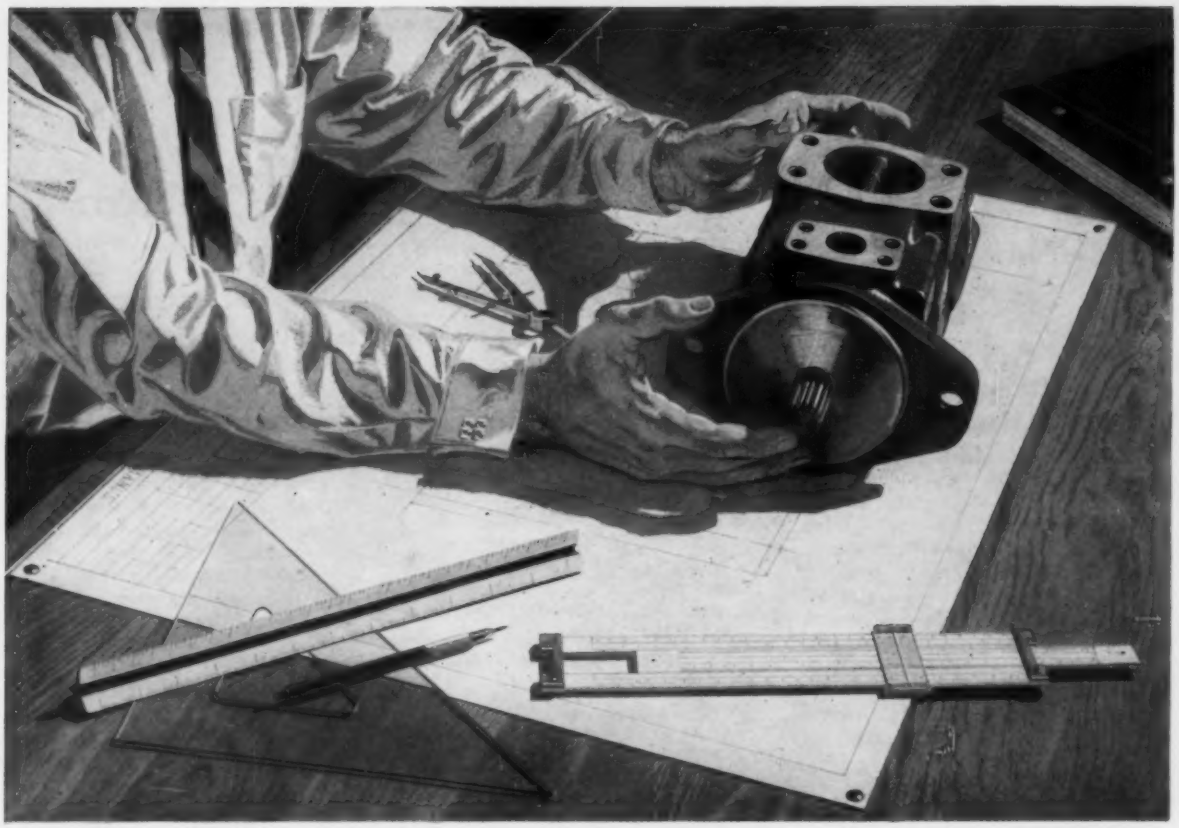
Filtration For Every Known Fluid

PUROLATOR

PRODUCTS, INC.

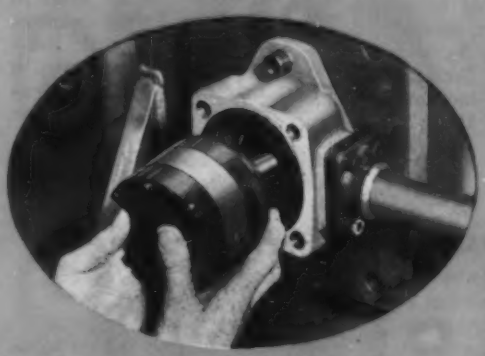
RAHWAY, NEW JERSEY AND TORONTO, CANADA

Circle **90** on Reader Service Card



IF YOU BUILD MOBILE EQUIPMENT...

VICKERS WILL MATCH A PUMP TO YOUR APPLICATION



10 minute field repair

Typical of the advanced design features available on Vickers pumps is the replaceable pumping cartridge in the "High Performance" series. A complete overhaul: cover removal, cartridge replacement, and cover replacement takes just 10 minutes in the field—no critical fitting or adjusting!

Customized designs or standard models—both are available from Vickers. Industry's broadest line of mobile pumps allows you to select the design that's best for you . . . saves you from paying for "too much" pump and from getting "too little".

Our application engineers can help you match your specifications with one of several thousand standard combinations of single or double pumps with choices of shafts, mountings, port connections, deliveries and direction of rotation. However, when unusual requirements demand special approaches, Vickers unequaled Research and Development facilities are at your service.

Whichever type of pump you select, wherever your equipment goes, there is the additional advantage of complete interchangeability of parts built in any Vickers plant located throughout the free world, providing full service coverage.

Additional data on pumps for mobile applications is available from your Vickers application engineer or by writing to address below. Ask for Bulletin P1.

VICKERS®

VICKERS INCORPORATED
DIVISION OF SPERRY RAND CORPORATION
Mobile Hydraulics Division
ADMINISTRATIVE AND ENGINEERING CENTER
DETROIT 32, MICHIGAN

9461

NEW LITERATURE

Circle the numbers on the Reader Service post card for free copies

INDUSTRIAL O-RINGS

Brochure describes how the same high quality control standards that govern this firm's manufacture of O-rings for aircraft and missiles are also applied to industrial types. Physical properties are given for the four compounds especially developed for O-rings used in general industrial sealing applications. Company is also a source for diaphragms, Permadized seals, Still-seal gaskets, and custom molding requirements.—*Stillman Rubber Co., Culver City, Calif.*

Circle **400** on Reader Service Card

MAGNETIC PLUGS, CHIP DETECTORS

Plugs used in transmissions, pumps, compressors, and hydraulic presses and jacks. Includes pipe-threads with square head and square recessed to 2"-11½ NPTF pipe size, and hex recessed to ¾"-14 NPTF. Straight thread cap screw type to 1¾"-12 UNF3A, and flanged to 2"-12 NF3A. Plug magnets of Cobalt horseshoe, and Alnico bar and horseshoe types. Booklet covers 500 plug types and sizes. Describes chip detectors for preventing system breakdown due to metal particles in lubricant. When gap between magnet and detector body is bridged by a metal chip, it completes an electrical circuit which actuates a warning light.—*Lisle Corp., Clarinda, Iowa.*

Circle **401** on Reader Service Card

DUAL RELIEF VALVES

Designed to relieve or charge a hydraulic or pneumatic system in either direction until a predetermined pressure differential is reached. When pressure at one port is greater than the other, poppet seats in valve having less pressure, stopping flow. When pressure at the same port is greater than the combined pressure of other port plus attached spring, valve under lower pressure opens, relieving excess pressure through high pressure port. Describes shuttle relief valve with built-in dual relief valves.—*Bachan Mfg. Co., Inc., Products Div., Madison Heights, Mich.*

Circle **402** on Reader Service Card

AIR CYLINDERS, CONTROLS

Descriptions of air-cylinders, valves, and controls given in 88-page Catalog 90. Single and double acting cylinders. Bore sizes 1½", 2", 2½", 3", and 4". Stainless steel rods. Adjustable rear and front cushions on all but 1½" size. Includes valve-in-head, accessory pin, built-in bleeder, 1½" stud-mount, and clamp type cylinders. Valves are double solenoid bleed pilot, single solenoid pilot, double solenoid pilot types. 2-, 3-, and 4-way. Sizes ¼" to ½". Sections cover feed tables and indexing units.—*Allenair Corp., Mineola, N. Y.*

Circle **403** on Reader Service Card

MINIATURIZED PUMPS, COMPONENTS

72-page Catalog 21 describes 96 basic models of miniaturized pump. Also shows hand pumps, standard and heavy duty pressure switches, relief valves, gauges, and a full line of cylinders from ½" to 4" bore. Complete section on accessories including tube and pipe fittings, hose, couplings, filters, strainers. Also a wide range of valves, heat exchangers, timers, accumulators, and electrical accessories. —*Oil-Dyne, Inc., Chicago.*

Circle **444** on Reader Service Card

BRONZE PISTON ROD COATING

Bronze is fused on surface of steel rod and ground to close tolerance. Fusing is done by high temperature spraying which forms a controlled porosity coating for good lubricant retention. Effective bearing length is increased by the length of stroke. This reduces wear. Standard rod diameters are ¾", 1", 1¼", 1½", 1¾", 2", 2½", and 3". Tolerance is + .0000-.0005 to 2" dia.; + .000-.0007 over 2".—*Thomson Industries, Inc., Manhasset, N. Y.*

Circle **404** on Reader Service Card

GAUGES

Pressure, vacuum, and compound indicating types. Construction includes snap ring, glass lens, T-gasket, pointer, dial, movement, system, socket seal pad, and case. Movement has no gears or teeth. Rigidized Teflon bearings. Cam facing is graphited Bakelite, eliminating distortion or wear. Included are accessories—valves, cartridge snubber, blow-out discs, heater, bleeds, and siphon. Catalog DH-54.—*Helicoid Gage Div. American Chain & Cable Co., Bridgeport, Conn.*

Circle **405** on Reader Service Card

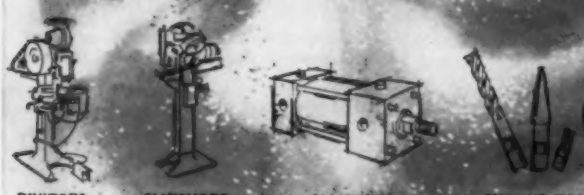
HYDRAULIC VALVES

Solenoid-operated 6-gpm valve. Pilot-operated, 30-gpm valve. O-ring sealed, nylon push pin guide bushings. Valve body ported and pinned to fit JIC standard panel. 6-gpm valves are single-solenoid, spring-offset; double solenoid, no-spring; double-solenoid spring centered. Pressures to 1000 psi. 30-gpm valves include external pilot control, integrally mounted,

Continued on page 58

BIG NEWS

The T-J Spacemaker cylinder line is not now, nor ever has been, a probe into outer space. It is offered as a practically designed, research engineered and time tested product. Its Spacemaker feature (no tie-rods) and rugged construction gives greater strength, saves space and reduces costs in all power drive applications. The Spacemaker is available in a complete range of bore sizes and strokes, air or hydraulic, and contains many *plus features* and extras as STANDARD . . . NO EXTRA COST! Write Tomkins-Johnson, 2425 W. Michigan Ave., Jackson, Mich. for Bulletin #155-4 and for full particulars, today.



T-J TOMKINS-JOHNSON
JACKSON, MICHIGAN

TRANSFER MACHINE BUILT BY BUHR MACHINE TOOL CO., ANN ARBOR, MICHIGAN

Automated GIANTS like this

REQUIRE STRONG HYDRAULIC *HEARTS* EVERY MINUTE OF THEIR WORKING LIFE

The precisioned flow control of RACINE PUMPS assures the split-second timing and efficiency required to operate this complex Buhr Transfer Machine . . . custom-built for the completely automatic machining of 120 auto-cylinder heads hourly for a leading automotive manufacturer. Compact RACINE VALVES control feeds and reverse movements on all 323 operations performed by the machine. RACINE 4-WAY SOLENOIDS help one man operate this mechanical giant. Buhr has used RACINE PUMPS and Reservoir Units on custom-built machines for the automotive industry for over 10 years.

24 RACINE PUMPS
operate this 58 station 500-ton transfer machine

RACINE

Racine Hydraulics & Machinery, Inc.
RACINE, WISCONSIN
HYDRAULICS DIVISION

Circle **91** on Reader Service Card

NEW LITERATURE

solenoid-operated pilot control. Two position, three-position spring-centered. 2000-psi pressure. Eight center-flow patterns.—*The DoAll Co., Des Plaines, Ill.*

Circle **406** on Reader Service Card

INDUSTRIAL VISES

Among vises added in literature are two PowRlock hydraulic heads, three Midget PowRlock holders, and complete assemblies for the Midget and the miniature PowR-lock.—*Wilton Tool Mfg. Co. Inc., Schiller Park, Ill.*

Circle **407** on Reader Service Card

AIR MOTORS, VACUUM PUMPS, COMPRESSORS

Six sizes of air motors, 1/20 to 7 hp. Explosion-proof and variable-speed. One capable of 12,000 rpm. Some are reversible. Compressor sizes from .6 to 45 cfm, 30 psig. Vacuum pumps from .6 to 50 cfm, 28" Hg. Both oil-less and lubricated models. Catalog 660 covers special accessories, prices, and specifications.—*Gast Mfg. Corp., Benton Harbor, Mich.*

Circle **408** on Reader Service Card

BALL VALVES

Catalog presents detail specifications and characteristics of industrial Flo-Ball valves. Cutaway drawings, phantom and exploded views, materials charts, pressure–temperature curves, and dimension tables are included.—*Hydromatics Inc., Bloomfield, N. J.*

Circle **409** on Reader Service Card

INDUSTRIAL SWITCHES

Snap action limit switches use mechanical latch or dog-locking mechanisms to hold the contact carrier locked. Actuation of switch energizes spring mechanism until latch or dog is released. Section of catalog 201 shows application of limit switches with emphasis on how to design actuating systems.

Continued on page 60

Circle 65 →

TEST MACHINE at a metal fabrication plant gets air from the Le Roi 100S2 shown below. Unit also supplies air for presses, automatic and manual welders, painting machines, and automatic assembly machines.

puts your plant air supply right where you need it!

LE ROI 100-HP STATIONARY COMPRESSOR

Trouble-free air-cooled LeRoi 100S2 delivers 450 cfm of air at 125 psi — yet takes up only 20 sq. ft. of floor space.

Any way you look at it, the Le Roi 100S2 two-stage stationary compressor is your best bet to lower your cost of compressed air.

It provides cool, clean airpower. And its compactness permits installation *near the point of use,* thus eliminating excess piping and costly waste of air. If you need more air, you just install more Le Roi S2 compressors — and you can still beat the cost of centralized air systems.

The electric-motor-driven 100S2 is easy to operate and maintain. Its Dual-Control permits either constant-speed or automatic start-and-stop operation. Air cooling eliminates plumbing and water line freeze-ups . . . permits indoor or outdoor installation. Balanced design reduces vibration and noise . . . extends compressor and motor life.

Put your compressed air system on a paying basis. Investigate the complete Le Roi line of unit-type and stationary air compressors — from ½ to 100 hp. Contact your Le Roi distributor, or write to Le Roi Division, Westinghouse Air Brake Co., Sidney, Ohio.

SC-05

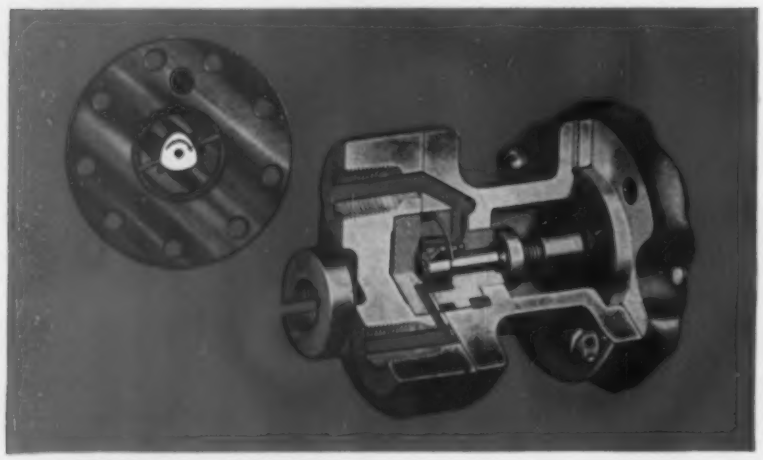
LE ROI STATIONARY COMPRESSORS

PORTABLE AND TRACTAIR® AIR COMPRESSORS • STATIONARY AIR COMPRESSORS • AIR TOOLS

YESTERDAY'S PIONEER . . . TODAY'S LEADER

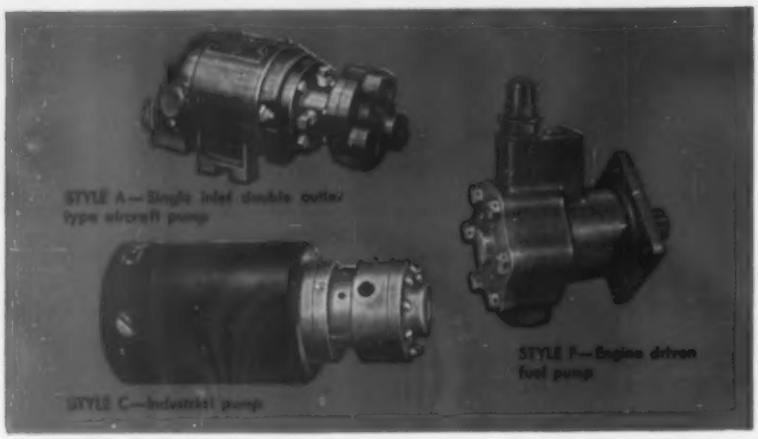
WELDON / FLUID METERING PUMPS

Positive Displacement Rotor Type. For Industrial Applications, Aircraft Anti-Icing and Aircraft Fuel.



IT'S SO SIMPLE!

The rotation of the rotor draws the fluid in through two passages, filling the cavities formed by the three lobes of the rotor. This fluid is sealed within these small cavities until it is forced through the two outlet holes by the floating blades. The flow may be kept uniformly divided through two outlet ports, or may be combined internally for passage through a single port.



COMPACT • LIGHT WEIGHT

Send for Weldon Manual and Catalog with detailed specifications and installation drawings, covering the full range of Weldon pumps in various capacities. Specify your requirements.

OVER 40 YEARS OF LEADERSHIP SINCE 1919

THE WELDON TOOL COMPANY

3000 WOODHILL ROAD . . . CLEVELAND 4, OHIO

Circle **117** on Reader Service Card

NEW LITERATURE

Special purpose switches such as remote control, air-operated, heavy duty plug-in, and switches for hazardous locations are shown. Bulletin 201.—*R. B. Denison Mfg. Co., Bedford, Ohio.*

Circle **410** on Reader Service Card

QUICK CONNECT COUPLINGS

Two bulletins contain complete specifications and details on this company's "E" and "H" couplings. "E" design is for high pressure, gravity flow, and vacuum systems; "H" for hydraulic use. Included is a catalog of spare parts, accessories, and methods of using the couplings. Bulletins 240-61, 250-61.—*Snap-Tite Inc., Union City, Pa.*

Circle **411** on Reader Service Card

AIR COMPRESSORS

Catalog covers air compressors for automotive, industrial, and contractor applications. Information on more than 200 gasoline and electric driven models featuring automatic start-and-stop and constant-running units. Compressors with horizontal or vertical tanks are described. Catalog 20.—*Lincoln Engineering Co., St. Louis, Mo.*

Circle **412** on Reader Service Card

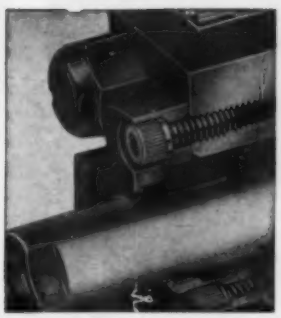
V-RING FAILURE

Major cause for V-ring packing failure is explained in Bulletin SS-461. Wear usually shows first as loss of material in sealing ring farthest from pressure medium. This is followed by progressive failure of succeeding rings. Cause of this wear is extrusion and nibbling loss of material. Portions of top sealing ring pass through gap between female adapter and surface sealed. As succeeding rings are no longer adequately supported, each ring in turn is deformed into the space vacated above.—*Greene, Tweed & Co., North Wales, Pa.*

Circle **413** on Reader Service Card

For more reviews of FREE LITERATURE turn to page 124

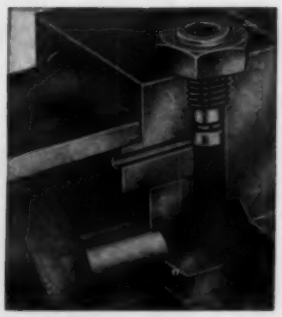
Do the cylinders you buy include these quality features?



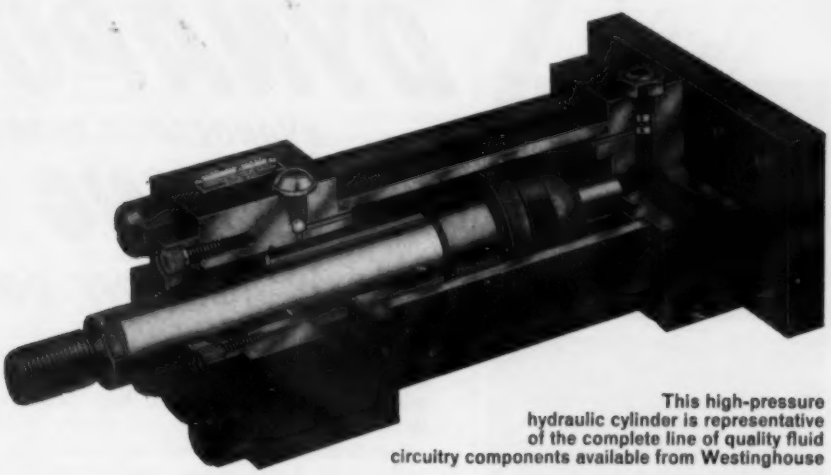
ROD GLAND—Easily removed. No need to loosen tie rods. Cuts maintenance time in half. Phenolic bearing insert will not score rod. Cuts replacement cost to a minimum.

ROD PACKING—Interlocking multiple lip seals require no adjustments; remain flexible under fluid pressure. Wear compensating function eliminates frequent replacement.

PISTON—Phenolic piston will not score tube. Packing cups used for proven long life and seal. Cups are easily replaced. Piston positively locked to rod.



CUSHION—Minimum clearance between piston and Meehanite Bushing combined with micrometer metering gives top cushioning efficiency and a wide adjusting range.



This high-pressure hydraulic cylinder is representative of the complete line of quality fluid circuitry components available from Westinghouse

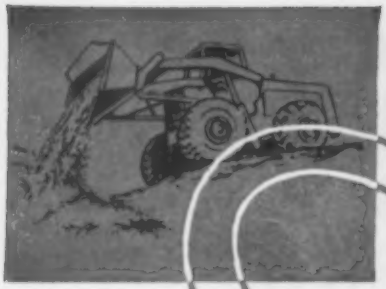
if not, the chances are, your maintenance costs are higher than necessary. For more information about Quality Fluid Circuitry Controls for trouble-free automation, ask for Catalog A3-56.00.

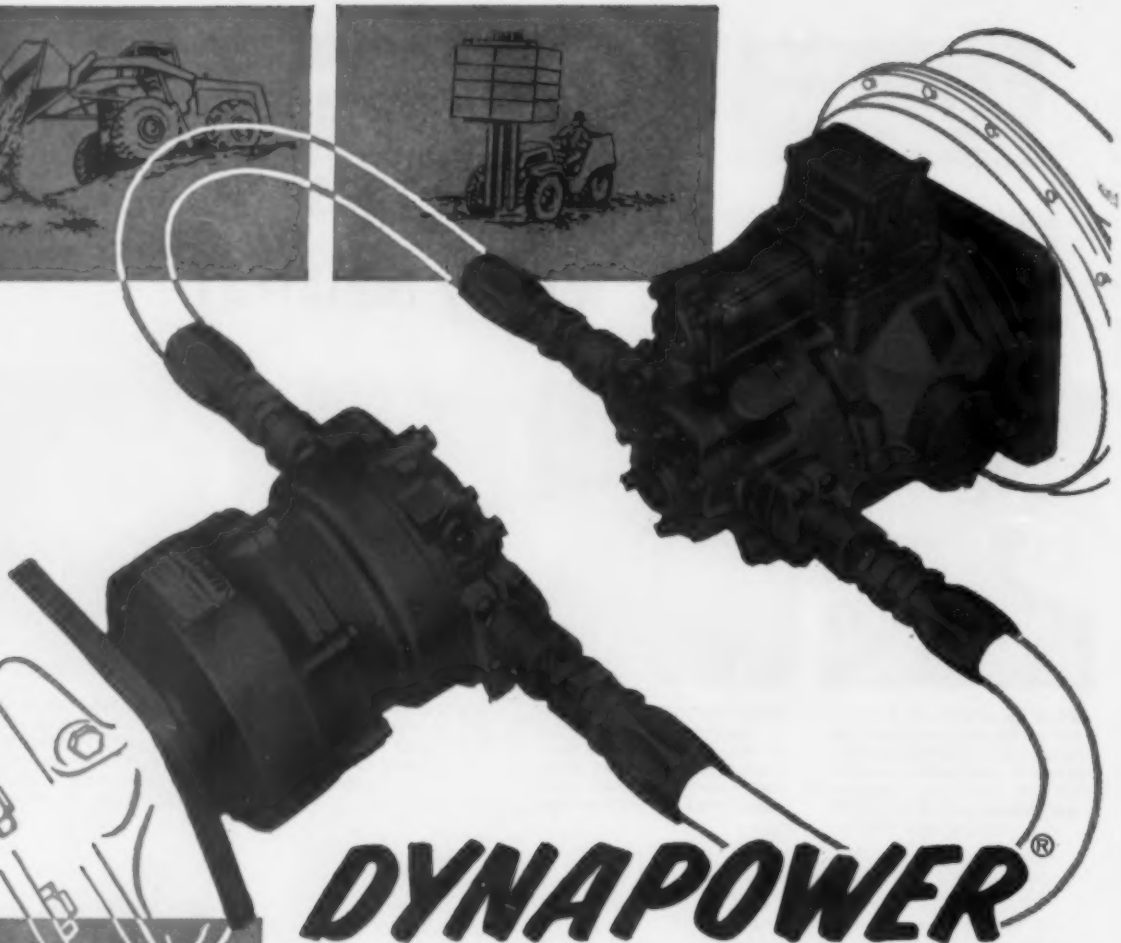
See the Yellow Pages under Cylinders for the Name of Your Local Distributor, or refer to Sweet's Catalog, Product Design File.

WESTINGHOUSE AIR BRAKE COMPANY

INDUSTRIAL PRODUCTS DIVISION, WILMERDING, PENNSYLVANIA

Circle **119** on Reader Service Card



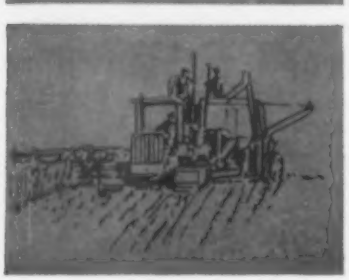


DYNAPOWER®

HYDROSTATIC TRANSMISSION SYSTEMS*

=SELLING POWER

in tomorrow's *OFF-ROAD VEHICLE* market



You can judge the pull of that SELLING POWER yourself. Take the outstanding sales points of your present off-road vehicle and add to them these unique DYNAPOWER benefits: high torque at low rpm; Power Absorption Braking® that eliminates use of service brakes; infinitely variable speeds in either direction without clutches or gear changers; faster, smoother response; and simplified maintenance due to elimination of the drive train.

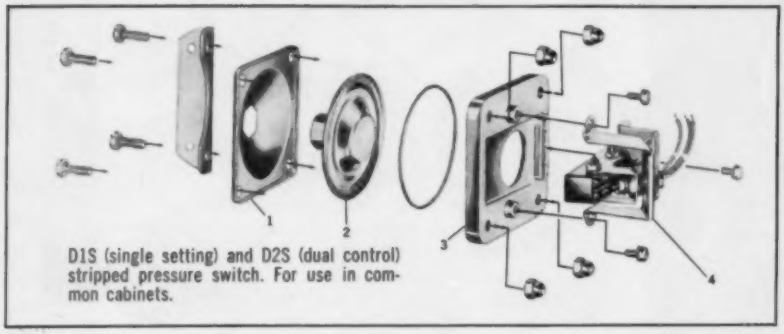
Then ask yourself, Could any other vehicle compete with one that offers all these? The answer is, No. That's why we say that DYNAPOWER-ed vehicles will dominate tomorrow's market. Be sure you are ready to compete in that market. Be sure you know all there is to know about DYNAPOWER today. Guarantee your own SELLING POWER in the competitive days ahead. Write:

*The DYNAPOWER Hydrostatic Transmission System shown above uses a separate axial piston hydraulic pump and motor to produce torque as required up to 300 lb./ft. The variable pump provides an infinitely variable speed ratio and displaces a maximum of 4.8 cu. in./rev. The transmission is rated at a normal 60 HP but handles peak requirements up to 90 HP.

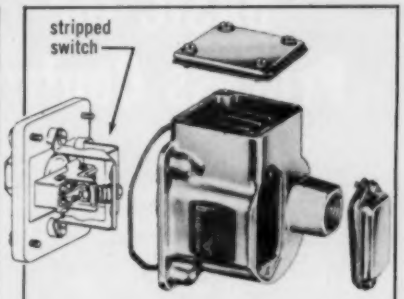
WATERTOWN DIVISION
THE NEW YORK AIR BRAKE COMPANY

128 STARBUCK AVENUE • WATERTOWN, N. Y.

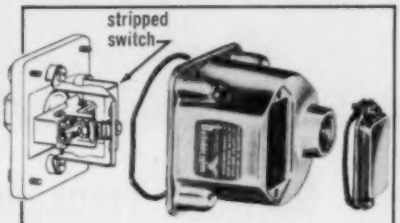
How to put 50% more accuracy into a pressure switch at 25% lower price



D1S (single setting) and D2S (dual control) stripped pressure switch. For use in common cabinets.



D1T (single setting) pressure switch with integral terminal block. Weatherproof housing.



D1H (single setting) and D2H (dual control) pressure switch with standard housing. Weatherproof.

The accepted standard of accuracy in pressure switches is ±1%. The new Barksdale diaphragm pressure switches are guaranteed for ± ½ % set and re-set accuracy (±0.2% if required). This instrument accuracy, unique proof (test) pressure characteristics, and remarkably easy servicing are accomplished by the use of a "basic unit" diaphragm assembly to which components are attached as required. The erector set principle permits production economies that are reflected in substantially lower prices. The entire concept of Barksdale pressure switches is the result of desired specification improvements as suggested by representatives of varied industries who were consulted before designing was begun.

The versatile basic unit

A leakproof, welded-metal sensing element (No. 2 in the photograph above) is surrounded by a heavy protective capsule (Nos. 1 and 3) which is independent of the sensing and switching elements. The hex of the pressure connection fits into a hex opening in the base of the capsule, preventing damage to the diaphragm should the unit be twisted during installation or removal. The standard pressure connection is ¼" npt female pipe fitting; ½" npt fitting is available when specified. The latter was requested by the petroleum industry to facilitate removal of paraffin accumulation and to permit attachment of switches directly to ½" pipe.

Diaphragms easily removable

Diaphragms may be removed without disturbing switch wiring, thus making it possible to change diaphragms to accommodate varying pressure requirements or to substitute diaphragms of different metals as fluid characteristics may demand. This feature cuts inventory costs for original equipment manufacturers because they need stock only diaphragms to meet their various pressure requirements rather than to stock complete switches in every category. It is important, also, to the petroleum industry because only diaphragms (not entire switches) need be carried by personnel doing field service.

Proof (test) pressures to 300 psi

The upper and lower sections of the diaphragm capsule are molded to fit the sensing element exactly. The top section prevents the diaphragm from stretching beyond normal curvature when surges above system pressure are encountered, and there is no possibility of metal distortion that would affect switch accuracy. In the low settings the new Barksdale pressure switches will actuate at 0.1" mercury with proof (test) pressure to 10 psi. In higher ranges they will go up to 300 psi proof (test) pressure at settings to 150 psi.

Stripped switch (single and dual control)

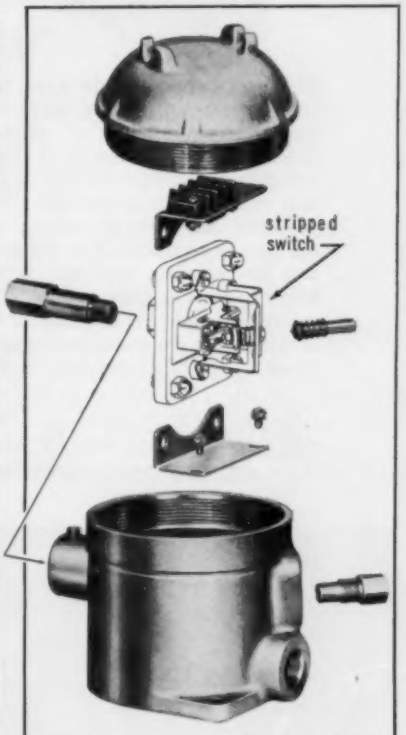
Addition of a switching element (No. 4 above) to the basic diaphragm unit makes a stripped switch for use in a common cabinet with other electrical devices. Original equipment manufacturers need not pay for unneeded housings. Extremely fine adjustment is possible because the adjusting screws have 64 threads to the inch. Adjustment may be made with a screwdriver or a wrench.

Housings added to suit

Addition of a sealed housing (standard, terminal block, or explosion proof) to a stripped switch completes a pressure switch that can be ordered "tailor made" for any desired application. In the standard housing, free wire leads are through a ½" nps conduit conductor. Wires are held firmly in place by a special tension clip that prevents disturbing the switch adjustment through careless wire handling. Terminal block housings are available for wiring convenience. Pottable electric outlets and external adjustment on explosion proof housings were suggested by the petroleum industry. Servicing instructions on all Barksdale switch housing are on the inside of a tamper proof cover to allow for painting of units.

Ask for new catalog

New Barksdale diaphragm pressure switches offer you something new in accuracy, proof (test) pressure, and economy. The just-printed catalog tells the complete story. Ask your Barksdale representative or write to Barksdale Valves, 5125 Alcoa Avenue, Los Angeles 58, California.



D1X (single setting) and D2X (dual control) explosion proof pressure switch. Pottable electric outlets. External adjustment.

BASIC for Process Control

Process engineers searching for a single source for a wide variety of products are sure to find the value of these American-Standard Controls Division products. This is true of anyone who must control or indicate the pressure or temperature of gases and fluids or electrical energy.

Pressure Gauges

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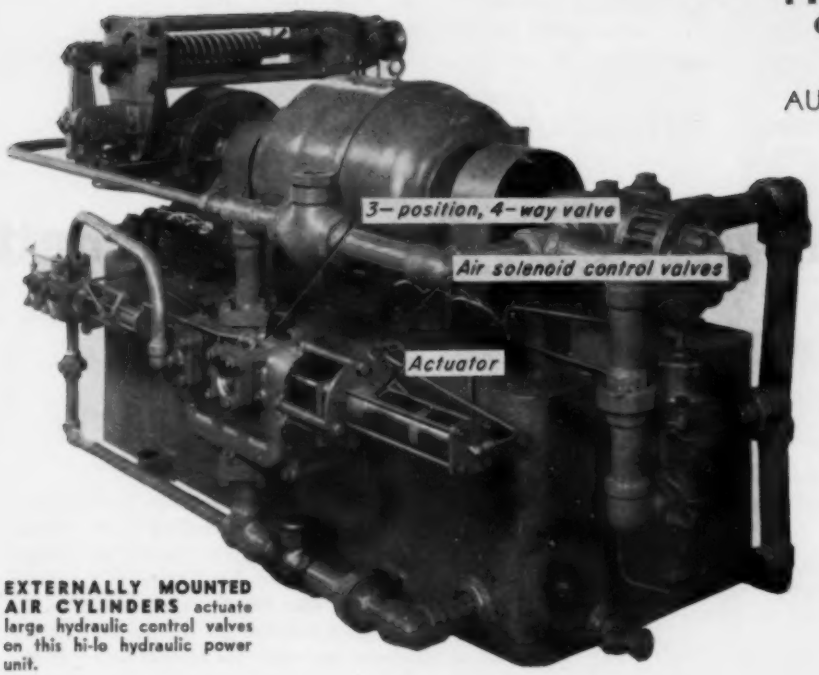
Hydraulics & Pneumatics

AUGUST 1961



EXTERNALLY MOUNTED AIR CYLINDERS actuate large hydraulic control valves on this hi-lo hydraulic power unit.

Should air cylinders actuate your valves?

• By **L. ARTHUR LASSMAN**, *Benjamin Lassman & Son, Glenshaw, Pa.*

RECENT trends in reducing overall size of hydraulic components have led designers away from air cylinder actuators for hydraulic valves. Integral hydraulic pilots take less space and are generally less costly. However, air cylinder actuators have many advantages to offset their higher initial cost.

The externally mounted cylinder lets you see the valve's operation, making it easier to locate trouble. Actuation speed is constant because viscosity of air does not change with temperature. Air speed control valves can often give the main valve a more sensitive control than oil pilot actuators because the air actuators have a greater volume.

Because an air pilot system has a separate energy source, the hydraulic valves can be actuated without operating the pump. When first starting a hydraulic system it can be completely cycled without putting oil in the lines. This dry run checks system functions and prevents damage which might be caused if pressure is applied before the system is properly timed. The hydraulic lines are also free of oil in case changes in piping are necessary.

Air purging a hydraulic system is easier with air cylinder valve actuators than integral hydraulic pilots. The pump can be jogged on and off to fill the lines slowly and gradually expell air. With an oil pilot system, pump pressure must be high enough to actuate the valves before they can be purged. This generally traps considerable air in the system.

If the main hydraulic valve fails to operate, the air pilot system can be quickly checked. An air line union or tube fitting can be loosened to test for air and no oil is lost.

Three-position valves can be positively centered without using springs. Air cylinders give a greater centering force than springs.

Air pilot operation is not limited to directional control valves. It can actuate pressure control valves, pump controls, etc. It is worth considering for high performance, heavy duty service. ▼▼▼

Measuring and counting contaminants in hydraulic fluids is usually done by laboratory technicians. The accuracy and reliability of these tests depend on the technician's skill. This tester does the job automatically, and is not influenced by human errors.

Measuring hydraulic fluid contamination

• By **LEON D. CARVER,** *President, High Accuracy Products Corp., Claremont, California*

TO MEASURE hydraulic fluid contamination it is necessary to:

- Obtain a representative fluid sample,
- Count and size the foreign particles,
- At times, to identify the contaminants.

The most common practice today requires that the sample first be filtered. The particles on the filter paper are then counted, sized, and, if necessary, identified under a microscope by a highly-trained laboratory technician. The instrument described here does this job accurately, regardless of the operator's skill.

• **Non-Automatic Methods**—It is usually left to the individual (person or company) to determine how best to obtain a *representative* sample of system fluid. Unless this is obtained the rest of the analysis is meaningless.

The time required for analysis is also of prime importance. Delays and holdups while waiting for results are costly. In addition, even though a valid sample was taken, it probably will not represent the system when reported at some later time.

The utmost in cleanliness of equipment and reagents used is required. Results are again dependent upon the technician's skill and available facilities.

Sizing and counting the particles under a microscope require the highest proficiency. Here, probably, arise the largest discrepancies from variations in individual techniques.

Minimizing human errors is done by establishing rigid procedures and using highly trained personnel. It is, however, difficult to compensate for physical fatigue, mental stress, variations in an individual's daily performances, and the pressure of having to do an analysis quickly. Thus, the ultimate results still depend on the individual, his ability to follow outlined procedures, and the fact that he is human and not a machine.

• **An Automatic Method**—The following describes the operation and advantages of automatic measurement of contamination using a precision instrument.

Fluid from the system to be tested is circulated through the unit. Turbulence is created in the mixing chamber to form a homogeneous mixture of the foreign particles. From here a continuous sample is taken for analysis. This sample then exactly represents all of the fluid that has passed through the instrument. No external contaminant can enter the sample before analysis. System fluid is used to flush the entire system, eliminating costly cleaning between tests. An accessory can be used to introduce a sample from a bottle whenever in-stream operation is not practical.

• **Phototube Counts, Sizes Particles**—The sample is drawn from the mixing chamber. It flows in a small stream through a beam of light which impinges on a phototube. When a particle passes, blocking out part of the light, a change in phototube output signal results. This change is proportional to the size of the particle, and is then registered on preadjusted electronic counters according to particle size.

Particle size is designated by the diameter of a circle that would have an area equal to that of the particle. For instance, a 10-micron particle has a projected area equal to a circle 10 microns in diameter. The particle need not be opaque for proper sizing. Translucent particles will be sized properly providing their index of refraction is different from that of the fluid. The fluid passage has a rectangular cross-section to minimize distortion of the beam of light. A circular passage would distort particles passing at the edge of the window compared to those passing at the center.

• **Sizing Fluid Passage**—To design the size of the fluid passage and its window, it is necessary to know the range of particle sizes and the maximum number of particles to be expected in the fluid. The passage must be large enough to pass the largest particles, yet small enough that the particles will pass the window one-by-one. This is a must, as the phototube cannot tell two small particles from one large one if they pass the window together. Particles need only be separated from one another by the height of the window for individual counting.

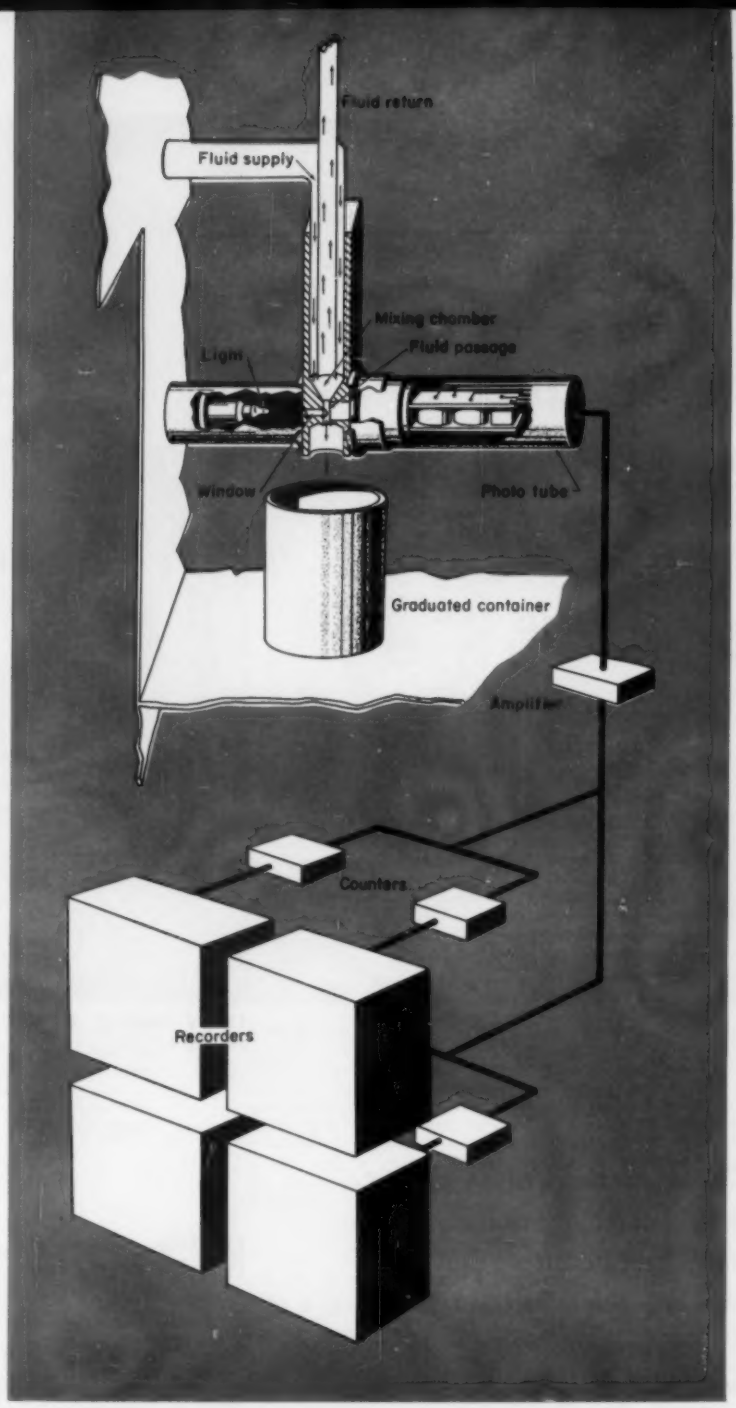
automatically

The volume of fluid that passes by the window at any one time can be obtained by computing the volume of the passage at the window. Dividing this volume into the total sample volume gives the number of complete changes of fluid that will flow past the window. Dividing this figure by the number of particles to be expected in the sample gives the ratio of complete volume changes past the window per particle. A ratio of 10:1 or more is adequate probability that the particles will pass the window one at a time.

• **Sizing Window**—The range of particle sizes determines the window size. Window width must equal the width of the fluid stream, so that no particle in the fluid sample can pass undetected. The window area must be small enough so that a signal from the smallest particle is strong enough to be distinguished from the inherent *noise* of the phototube. The window must also be as high as the largest particle. Thus, particles larger than the range being counted will be recorded, although their size can only be indicated as larger than the largest size being recorded. To determine contamination origin, the sample is filtered, and examined visually or spectographically.

• **Parallel Light Source**—A parallel beam of light insures that each particle blocks out the same amount of light regardless of how close it passes to the window. A diverging light beam would make particles near the window appear larger than those farther back.

• **Compensating for Fluid Density and Color**—To obtain proper sizing regardless of fluid density and color, a potentiometer adjusts intensity of the light source. A milliammeter monitors the phototube output, and the operator sets this to the calibrated value by adjusting the light intensity at the start of each analysis. ▼▼▼



SAMPLE IS CONTINUOUSLY DRAWN from mixing chamber in main stream. Fluid flows past window where particles interrupt light beam, causing phototube signal change. Signals are amplified and sent to counters where they are tallied according to size.

Hydraulic circuit breaker keeps watch on itself

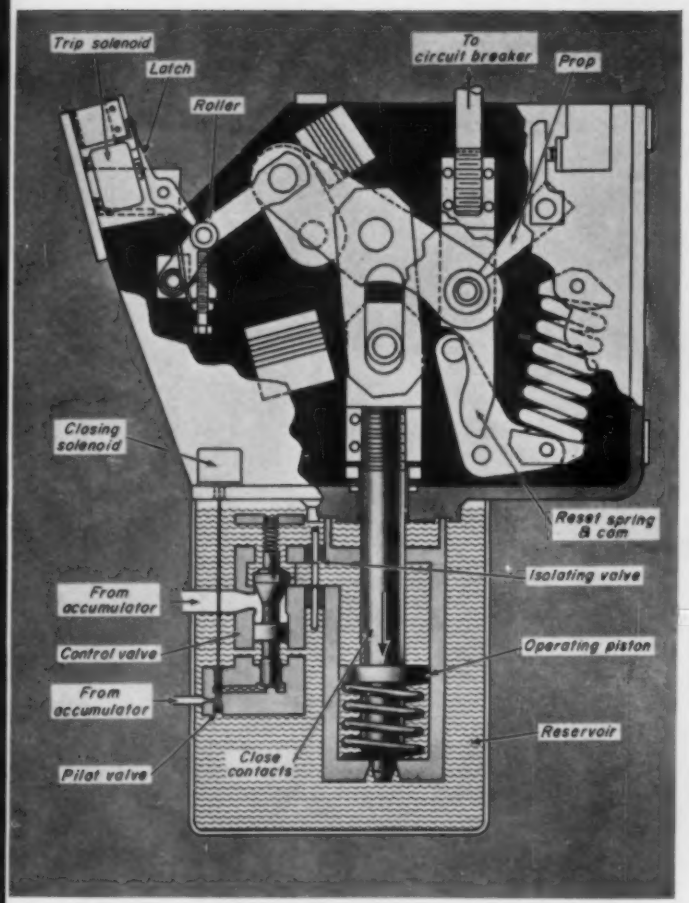
• By **UGO R. TOGNELLA,**
Design Engineer and
GEORGE C. McBRIDE,
Senior Design Engineer,
Switchgear and Control Div.,
General Electric Co.,
Philadelphia, Pa.

138-KV CIRCUIT BREAKER has hydraulic closing mechanism in the cabinet in front.

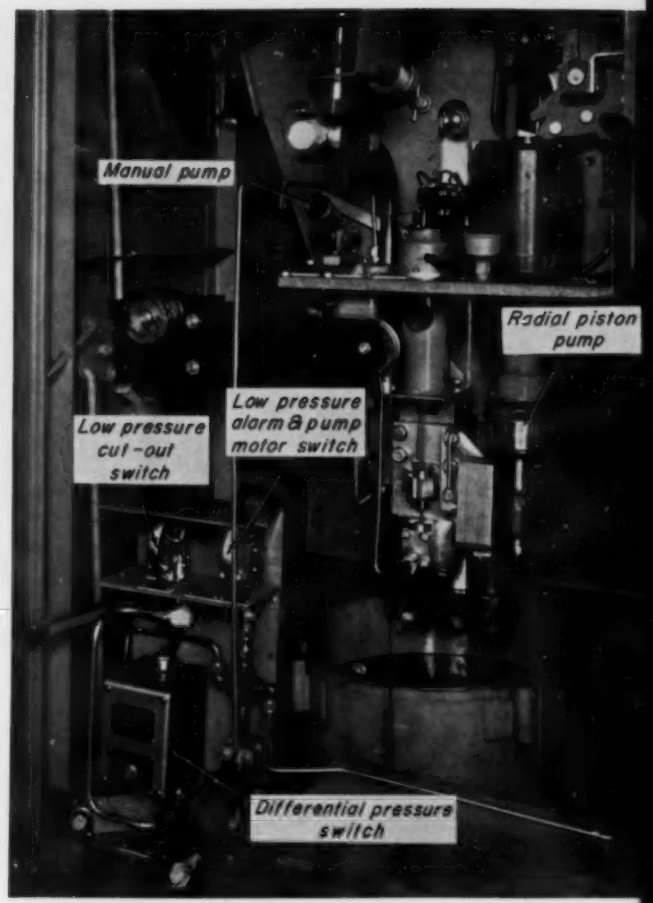
Circuit breakers which protect high voltage, transmission lines don't operate often, but when they do, they must not fail. Use of pressure switches to monitor accumulator gas and oil pressures keeps these recently designed breakers alert.

HIGHER voltages and heavier electrical loads require larger, faster circuit breakers. Now, hydraulic actuation has been introduced to close larger breakers. The accumulator system which actuates the hydraulic contact-closing mechanism is maintained at high pressure for long periods, yet must operate reliably.

A piston accumulator stores closing fluid under 3000 psi pressure to close the circuit breaker quickly after it opens under an electrical overload. Normal accumulator capacity is sufficient for five closings without repressurizing. A pressure switch monitoring system oil pressure controls the electric motor and pump to maintain normal pressure within a narrow range. A small system leakage is provided so that the accumulator piston moves slightly each day, and so that the pump operates several times a day. This prevents sticking and indicates the pressurization system is working.



CONTACT CLOSING MECHANISM is actuated when the pilot valve opens the control valve. Then the spring-loaded, main piston retracts. Both the pilot and control valves have overbalanced, piston-poppet spools. The isolating valve is closed during inspection and maintenance of the linkage. With the cylinder isolated from the control valve, the manual pump supplies oil pressure.



RESERVOIR HAS BEEN LOWERED to show the hydraulic operator which is normally entirely submerged in oil. This oil bath produces a short, low resistance, exhaust line from the cylinder. The two pressure switches have Bourdon tube pressure response elements. The differential pressure switch is just underneath the pressure switches. The manual pump supplies pressure during maintenance and inspection of the linkage. During electric power outage, the manual pump can replace the electrically-driven, radial piston pump to charge the accumulator.

The pressure switch has a second function. If pressure drops, the switch sounds an alarm while there is still enough pressure in the accumulator to operate the breaker three times.

A pressure switch monitoring *gas* pressure prevents operation of the closing cylinder if pressure is not high enough to close the circuit breaker quickly and completely. Slow breaker closing could result in arcing damage to the contacts.

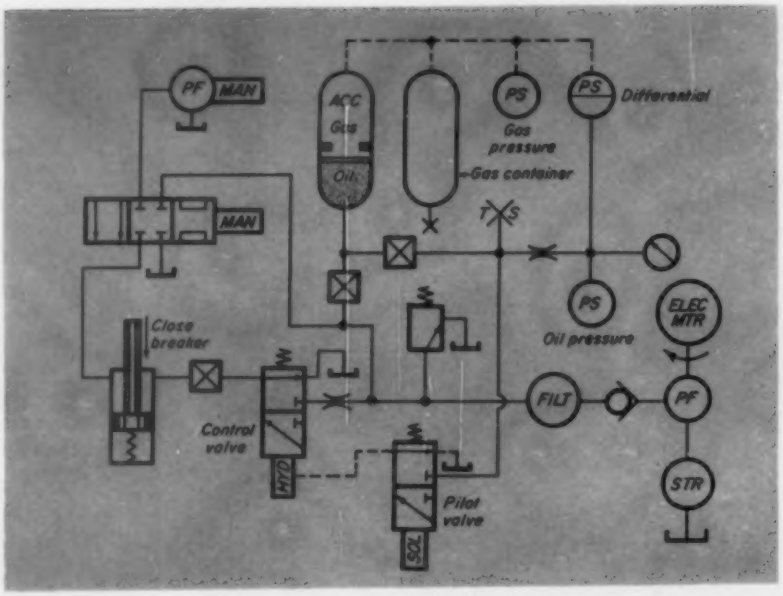
• **Loss-of-Gas Detection**—A disadvantage of the usual hydraulic accumulator is that it is difficult to detect small losses of gas while the accumulator is at operating pressure. If there is a loss, more oil is pumped into the accumulator to maintain normal pressure. Eventually, enough gas might be lost so that there would not be enough energy stored in the accumulator to close the circuit breaker properly.

To avoid such problems this circuit breaker has a loss-of-gas detection system. After a predetermined loss of gas, the free-floating accumulator piston bottoms on a mechanical stop. Continued loss of gas lowers gas pressure. A differential pressure switch compares gas and oil pressures. If these are not the same, the pressure switch actuates an alarm or prevents the solenoid-operated pilot valve from opening.

• **Closing Mechanism**—In addition to the accumulator system, the high speed, contact-closing mechanism consists of control and pilot valves, operating cylinder, and mechanical linkage.

The pilot valve is a solenoid-operated, overbalanced piston-poppet type which operates the overbalanced, piston-poppet control valve. The control valve is a high-speed, high-flow type with the right combination of solenoid, spring, and hydraulic forces for rapid movement. Overbalancing means the diameter of the balancing spool is slightly greater than the diameter of

HYDRAULIC CIRCUIT BREAKER



ACCUMULATOR SYSTEM has auxiliary gas storage for added volume to increase system capacity. The gas bottle contains nitrogen at 2000 psi when fully charged. The 10-gal piston accumulator capacity (including the auxiliary bottle) is sufficient for 5 closings without recharging. The piston's O-rings are rubber backed with Teflon. A loss-of-gas detecting system sounds an alarm while there is still sufficient energy stored in the system to operate the breaker three times.

the poppet seat. Thus, under pressure there is a force tending to close the valve. This helps achieve faster valve closing.

If a second overload occurs during the circuit breaker's closing motion, the breaker can be reopened. The hydraulic system or mechanical linkage can instantly reverse the closing motion of the circuit breaker by either closing the control valve to quickly exhaust the oil in the operating cylinder, or allowing the linkage to collapse.

DEVELOPMENT OF CIRCUIT BREAKER SYSTEMS

Systems to close circuit breakers have advanced through manual, motor driven, solenoid, and pneumatic actuation as power requirements have increased. The *pneumatic* operator stores a large amount of energy in a reservoir while using only a small power source to operate a compressor. The stored energy is used at a high rate to operate the breaker. An *oil* system has this same feature, and it has other advantages which make it increasingly attractive as power requirements mount. Response is much faster because oil is only slightly compressible. Also, air must be used at moderate pressures for economy, whereas a 3000-psi hydraulic system is practical. Thus, higher operating pressure and inherently faster response result in a hydraulic system which is more compact and requires less input power. The hydraulic operator supplements existing pneumatic operators.

These operating characteristics are known as *hydraulically trip free* and *mechanically trip free.*

• **Rapid Oil Exhaust**—Hydraulically trip free operation depends on rapid ejection of oil in the cylinder. A large diameter line connects the operating cylinder with the control valve. Both are immersed in the reservoir. This produces a short, low resistance, exhaust line from the cylinder, and also reduces the effect of slight gasket and pipe joint leaks. The rapid drop in oil pressure allows unimpeded piston motion, allowing the breaker to open quickly.

The operating piston is connected to the circuit breaker through the mechanically trip free linkage. The linkage can separate the circuit breaker from the piston at any point in the piston's closing stroke. For mechanical opening, the *trip* solenoid opens the breaker by rotating the latch away from the roller, permitting the linkage to collapse. After the overload has passed, the reset spring and cam return the linkage to the latched position. The hydraulic operator will then reclose the contacts within ¼ sec.

Thus, the breaker can be tripped open at any time, even though there is an electrical, hydraulic, or mechanical failure. This ability to open under any condition is extremely important since failure to open can result in extensive damage to the electrical transmission system which the breaker protects.

• **Manual Operation**—Breaker contacts can be operated manually for adjustment and inspection and for maintenance of the linkage. This is done by isolating the cylinder from the control valve and then supplying oil with the manual pump. This allows the breaker to open and close slowly. The manual pump may also replace the electrically-driven pump should electric power be unavailable to charge the accumulator. ▼▼▼

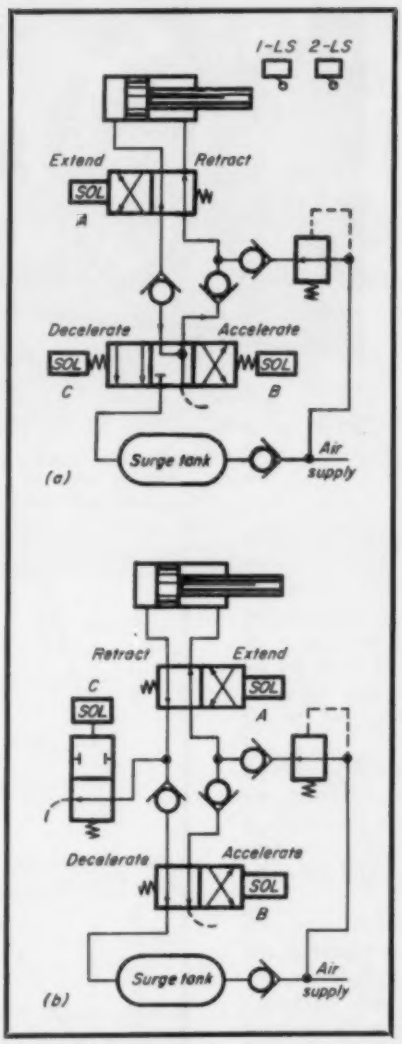
Acceleration/deceleration circuit saves air

• By **JAMES A. NEFF,** *Vice President, Mechanical Air Controls, Inc., Detroit, Mich.*

COMPRESSIBILITY of air is used to advantage in this circuit to control cylinder movement. The cylinder is stopped by making it work as a compressor, converting kinetic energy of the moving mass into stored pressure in a surge tank. Pressure in the surge tank then accelerates the cylinder on its reverse stroke. The action is duplicated for extending and retracting the cylinder.

In circuits with small air valves (to $\frac{3}{8}$-in.), only two valves control the circuit. This arrangement is shown in circuit (a). A 4-way, single solenoid valve controls piston direction, and a 4-way, 3-position, double solenoid valve regulates acceleration, deceleration, and exhaust. For efficient operation, pipe lines must be kept short, check valves must be leakproof, and the surge tank sized to the job.

• Trapped Air Holds Cylinder—An electrical signal to extend the cylinder energizes solenoids *A* & *B*. The control valves shift, and air from the surge tank and supply line accelerates the cylinder. At some point in the stroke, determined by the position of limit switch 1-LS, solenoid *C* is energized and solenoid *B* is de-energized. The cylinder decelerates by gradually building up pressure in the surge tank. At the same time, air is cut off from the head end of the cylinder. Air pressure already in the cylinder's head end is held by the check valve and expands during slow down. At the end of the stroke, 2-LS is actuated, de-energizing solenoid *C* and centering the 3-position valve. The cylinder's rod end exhausts and residual air pressure in the head end holds the cylinder extended. Air that leaks out of the cylinder is replaced by air through the pressure regulating valve.



SURGE TANK decelerates cylinder and stores air to accelerate it rapidly on reverse stroke.

To accelerate and decelerate the cylinder while retracting, solenoid *A* is de-energized. The 3-position valve shifts in the same sequence as it did while extending the cylinder. It accelerates fast because only low pressure, residual air remains in the head end of the cylinder.

In circuits using larger valves (to $1\frac{1}{4}$-in.), a $\frac{3}{8}$-in. shutoff valve is used to exhaust the cylinder at the end of the stroke and during acceleration. This arrangement is shown in circuit (b).

If mid-stroke stopping or inching the piston are required, the directional control valve can be replaced with a 3-position, closed center valve. The two energized positions give directional control to the piston and the center position blocks both cylinder ports. Manual control of the valve then inches the piston in either direction. This would also be a fail-safe circuit because if electrical power failed, the cylinder would stop.

• Air Saving—The circuit saves air by using supply pressure for only part of the stroke, and returning a large quantity of air to the surge tank for use during the next cycle. The only air expended is air exhausted at the end of the stroke, and residual air in the cylinder exhausted at the start of the reverse stroke. ▼▼▼

Cams control mobile platform travel speeds

• By **PAUL L. GERARD,** *Manager*
Vickers, S. A., Paris, France

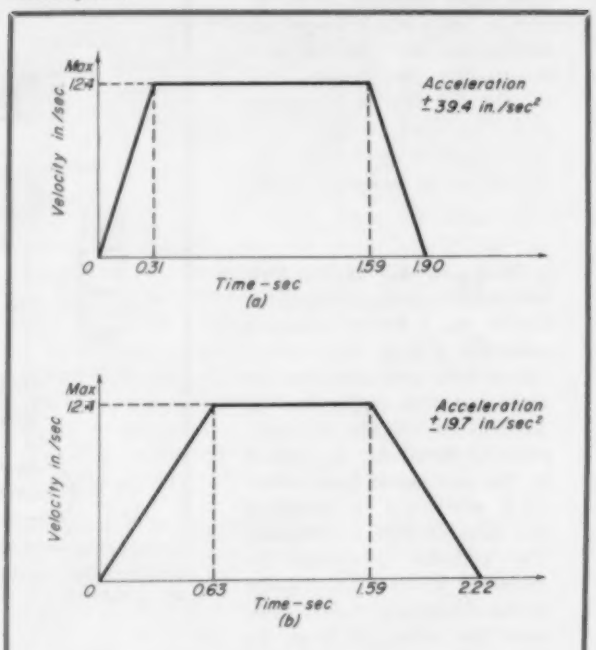
ASSEMBLY LINE workers ride their platforms to and from the assembly line.

AT SIMCA auto plant at Poissy, France, car bodies roll down the assembly line and stop at various stations for different assembly and welding operations. When a car body stops at a station, two hydraulically actuated platforms (one on each side) move up to it. Assembly workers and tools ride to and from the assembly line on these platforms. After they have finished their jobs, the platforms withdraw, and the car body moves on to its next station.

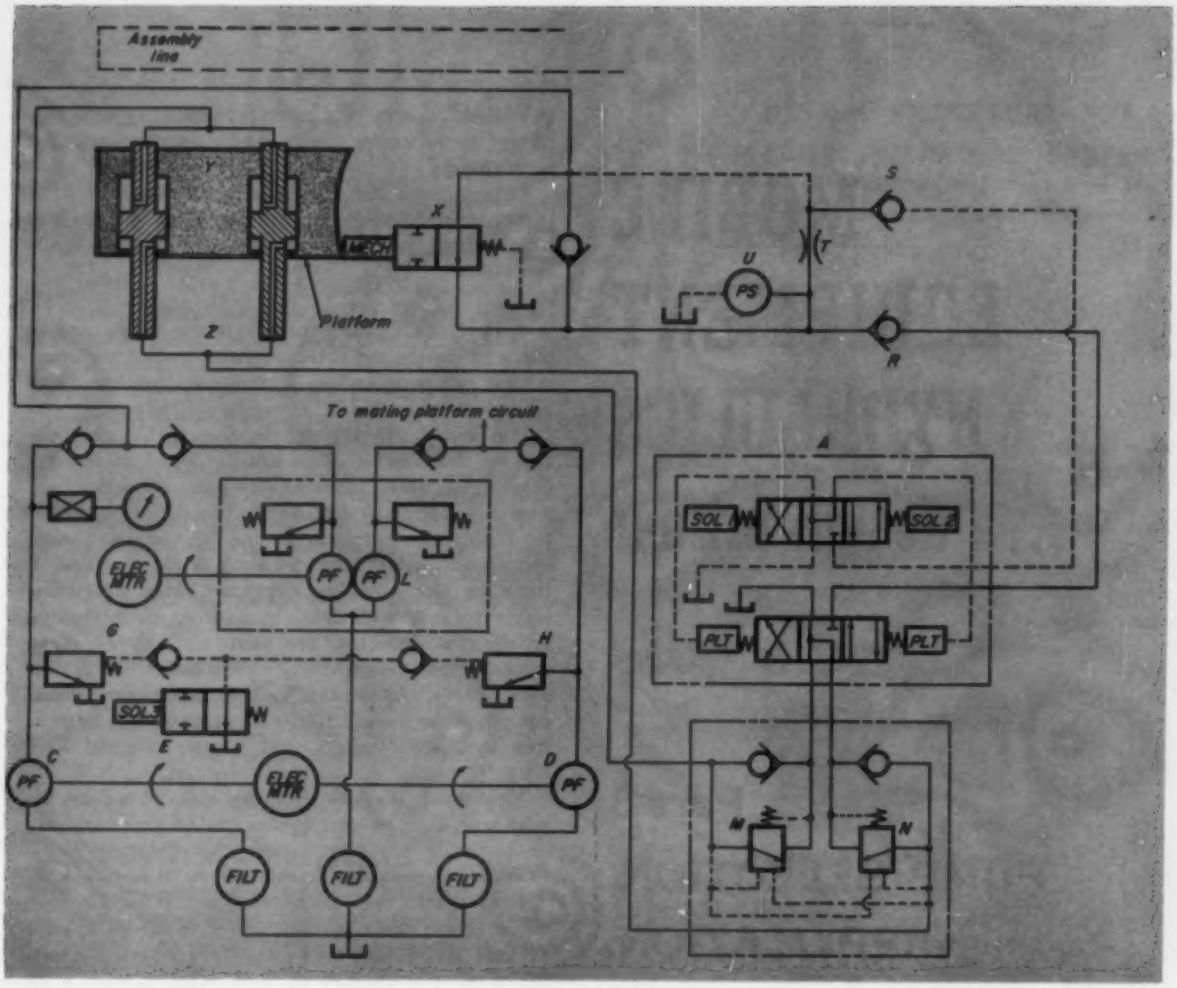
To prevent workers from being jarred or thrown from their platforms, maximum and minimum acceleration and deceleration speeds were calculated. It was decided that optimum acceleration or deceleration would be between 0.5 meter (19.7 in.) and 1.0 meter (39.4 in.) per sec^2.

Sets of twin, double rod-ended cylinders move each platform back and forth. To insure simultaneous and symmetrical movement of each pair of platforms, separate, identical sets of pumps drive each platform's cylinders. Cams on the platforms actuate deceleration valves which control platform acceleration and deceleration speeds. The advantage of this design is that inertia causes no pressure peaks in the cylinders.

It was calculated that when valves *G* and *H* (on the circuit diagram) are set at 286 psi, and counterbalance valves *M* and *N* are set at 80 psi, pressure drop across deceleration valve *X* is the same regardless whether the platform is accelerating or decelerating.



MAXIMUM ACCELERATION of 39.4 in./sec^2 (a) was calculated as safe and comfortable for workers traveling on platform. Minimum acceleration and deceleration of 19.7 in./sec^2 (b) was necessary for efficient assembly line operation.



For this reason, it was estimated that with symmetrically shaped cams, the time vs. distance curve (see illustrations) would also be symmetrical.

HOW THE PLATFORM SPEED CONTROL WORKS

In the actual installation there are four identical assembly stations. For simplicity, only one station is shown and described.

Each section of double pump *L*, with its mating pumps *C* or *D*, powers a set of two double-ended, rod-fed cylinders.

To move the platform toward the assembly line, solenoid *2* of valve *A* is energized. Pilot pressure shifts valve *A* which pressurizes the cylinders moving the platform to the work. At the same time it supplies pilot pressure to open counter-balance valve *M* so that exhausting fluid from the assembly line side of the cylinders can return to reservoir.

When the platform reaches the end of its travel, pressure switch *U* is actuated. This *de-energizes* valve *E* connecting the relief valve vents to tank and unloading pumps *C* and *D*. For opposite platform movement, solenoid *2* of valve *A* is de-energized and solenoid *1* energized. Combined deliveries from pump *C* and one section of pump *L* move the platform back from the assembly line. Fluid from the assembly line side of the cylinders now drains to tank through counterbalance valve *N*, which is held open by pressure on the far end of the cylinders.

As the platform starts back, deceleration valve *X* opens. The platform travels at full speed until the opposite cam engages and begins to close valve *X* for deceleration.

Check valve *S* in the valve pilot line prevents valve *A* from spring-centering itself in case of a drop in system pressure. Flow control valve *T* in parallel with deceleration valve *X* performs two functions: it meters oil to insure pressure to complete a cycle movement, even though the cam may have completely closed off valve *X*; it also synchronizes the mating platforms. When valve *A* is centered, all cylinders are connected to tank. Internal piloting in counterbalance valves *M* and *N* insures dampening action in case of electrical failure. ▼▼▼

MOBILE EQUIPMENT HYDRAULICS ...a design primer

Part 3

PUMP SELECTION, APPLICATION, and MAINTENANCE

• By **RUSSELL W. HENKE**, *Director of Research*
Racine Hydraulics & Machinery, Inc.
Racine, Wis.

OVERALL quality of a pump is reflected by such factors as efficiency, service life, construction, and serviceability.

To determine the degree of quality needed in a particular application, mobile equipment pumps can be classified for low, medium, or high duty cycle operation.

• **Low Duty Cycle Pumps**—Where safety due to pump failure is not a factor, requirements for intermittent pump operation at moderate pressure (800-1200 psi) led to design of low duty cycle pumps.

Pumps for this type of service are of generally coarser construction than usually found in the hydraulics industry. Tolerances on parts are wider, and assembly tolerances are usually broader. Economy is the major consideration, though they are well engineered, adequately constructed units for the applications for which they were intended. Most unsatisfactory experience with them results from misapplication or overloading. They are used on highway dump trucks, refuse collection equipment, hoists and cranes, snow plows, equipment trailers, some agricultural equipment, and small construction equipment such as trenchers, small rollers, and tractor mounted back hoes.

Most pumps designed for this class of service are gear type, because gear pumps can be produced very economically. Average volumetric efficiency is 85 to 90% and overall efficiency about 70 to 85%.

Most pumps for low duty cycle service are foot-mounted and universal-joint driven, although in some agricultural installations a flange mounting on the tractor power take-off may be used. Many pumps in the class are made with integral valving, including directional control, check valves and relief valves.

Low duty cycle pumps cost about three to five dollars per horsepower. Capacities range from 5 to 100 gpm at 1000 psi and 1000 rpm.

• **Intermediate Duty Cycle Pumps**—Pumps for this type of duty are generally higher quality gear pumps, and mobile type vane pumps.

Gear pumps in this class are precision built. They usually have pressure-loaded wear plates for increased volumetric efficiencies, anti-friction bearings, and finely finished parts. Volumetric efficiencies are usually about 90-95% with overall efficiency of 85-90%.

Gear pumps are often used in mobile applications because they have relatively simple design with few moving parts, are easily serviced by inexperienced help, and have good contamination tolerance. They are inherently unbalanced and this causes bearing loads which limit operating speeds.

Vane pumps using balanced rotors to keep bearing loads low are also used frequently in mobile applications. Mobile vane pumps are usually rated at 2000 psi.

Intermediate duty cycle pumps cost about four to six dollars per horsepower.

Typical applications include:

- Bulldozers
- Scrapers
- Front End Loaders
- Graders
- Trenchers
- Fork Lift Trucks
- Crawler Tractors
- Excavators
- Mining Equip.
- Back Hoes

• **High Duty Cycle Pumps**—When the application places severe demands on the pump; such as continuous operation, high pressures, damaging operating environments, or the circuit requires the characteristics of precision type pumps, high quality vane and gear pumps, piston pumps, variable delivery pumps, and pressure-compensated pumps are used. Volumetric efficiencies are in the 90 to 97% range and overall efficiency is 90 to 95% at rated delivery and pressure. Piston pumps are capable of working at pressures up to 6000 psi. Cost is about 12 dollars per horsepower, at these maximum ratings. The cost of any pump per horsepower will go up, if it is not used to its maximum capabilities.

Typical applications include:

- Hydrostatic Drives
- High Pressure Circuits
- High Horsepower Circuits
- Continuous duty circuits with widely variable loads
- Closed center circuits.

CIRCUIT REQUIREMENTS

In designing most mobile hydraulic circuits, maximum system pressure is determined from the load which must be handled and the net effective area of the actuator used to move it. If the circuit has a number of branches, pressures for each branch must be calculated. The highest branch pressure determined will then represent maximum required pump capability.

Having established the maximum system pressure it is necessary to find out how long or for what percent of the total cycle this pressure is needed. In some applications it is only momentary—a break-away pressure, after which running pressure drops to a lower value. In other applications, the high pressure operation will be continuous or will last most of the time.

The next major factor in pump selection is required capacity and pump displacement. Some mobile pumps are rated in gpm at 1000 rpm. It is generally preferable to convert this rating to cubic inches or gallons per revolution.

Pump capacity is determined by the size of the actuator and the time to extend or retract it. For example, a cylinder of 6″ bore and 20″ stroke has a volume of about 576 cubic inches or about 2½ gallons. If the designer feels that its cycle should be 10 seconds for a full stroke, displacement would be 2.5/10 x 60 = 15 gpm. This is the amount of fluid the pump would have to deliver to extend the cylinder in 10 secs.

These calculations must be made for each circuit branch. Capacities for operations which happen together must be added.

When a fixed displacement pump is used without

DESIGN PROCEDURE FOR MOBILE HYDRAULIC SYSTEMS

Checklist for designing Mobile Equipment hydraulic systems

A. Circuit Requirements

1. Maximum pressure
2. Average pressure
3. Possibility of shock loading
4. Relative time proportion between maximum pressure and average pressure.
5. Maximum flow required.
   a. Constant or variable
   b. Duration
6. Average flow rate
   a. Time proportion between maximum flow and average flow
   b. At what pressure?

B. Application considerations

1. Pump drive
2. Pump mounting
3. Available drive speeds
4. Available drive horsepower

C. Life

1. Pump life at circuit pressure
2. Pump speed
3. Operating environment
4. Cycling
5. Shock loading

D. Maintenance requirements

1. Field maintenance
2. Access and removability
4. Preventive maintenance program

E. Types of fluids likely to be used.

1. Motor oil
2. Transmission or brake fluid
3. Kerosene
4. Crankcase oil
5. Hydraulic fluid

F. Economic considerations

1. Cost, life, and quantity of mobile equipment
2. Replacement cost and volume of hydraulic components
3. Availability of components
4. Customer acceptance of components.

provision for unloading, part of its output will pass over the relief valve at maximum pressure when system operation does not require full pump capacity. A pressure-compensated variable delivery pump or unloading arrangement is helpful in limiting heat generated by wasting energy in this way.

• **Pump Drive Speed**—In most mobile applications, pump drive speeds are a fixed ratio to engine speed. Usually the pump runs at less than maximum speed during the operating cycle. Thus the pump must deliver an adequate amount of fluid at minimum engine speed and be able to stand the higher speed at maximum engine rpm.

This is usually not a problem with pumps driven from a power take-up, but it is important with flange-mounted pumps driven directly by the engine. Here again, variable delivery pressure-compensated pumps have an advantage in being able to cope with these widely divergent operating conditions.

A second factor related to driving pumps is available horsepower. The power take-off accessory drive, fan belt, or any other drive must be able to deliver enough horsepower to the pump, taking into consideration efficiency factors, for it to meet all requirements during all parts of the cycle.

• **Pump Life**—This is related directly to bearing life, and is given in hours of running time. It indicates fatigue characteristics of the bearing races, and rollers or balls, and also depends on loading and speed. Shock loads on bearings can be far in excess of design running loads. One of the greatest dangers of shock loading a bearing is that the rolling member might permanently indent the race. This is termed *brinelling*. Each rolling element passing over this depression drops in and out of the indentation. The bearing will fail rapidly under such operating conditions.

• **Shock**—Various means can be used to minimize transmission of system shock back to pumps. A free flow check valve on the pump's discharge side will help. Relief valves are expected to open and relieve pressure shocks, but this doesn't always work because response time of most relief valves is too long. The shock wave moves so fast that it goes right by the relief valve which doesn't open until static pressure builds up high enough. At least one company manufactures a shock suppressor valve which operates on rate of pressure rise and bleeds off the energy of the shock wave. An accumulator in the line can also be effective.

MAINTENANCE

The maintenance factor is an important consideration when selecting a pump for mobile applications. In some of the tougher installations, like off-the-highway construction and mining equipment, the goal may well be to get a pump which will run between normal overhaul periods on the vehicle itself.

There will be some failures which put equipment out of service. The pump installation should be designed so that a replacement pump can be mounted fast. This means allowing for adequate accessibility to the pump. Field replacements are made under the most adverse conditions and thoughtless design should not add to the problems.

• **Service Facilities**—Another consideration for pump selection related to maintenance, is the type of facilities and personnel which will likely be servicing the equipment. If the vehicle will be operating in some advance outpost of construction, mining or military operation, one can be fairly sure that maintenance facilities will be meager. The simplest pump which will do the job will probably be the best in this case. As better maintenance facilities become available, the more complicated pumps, better suited to actual circuit requirements, can be considered.

The ideal situation is when the vehicle is returned to a central maintenance depot for regularly scheduled overhaul by specialists. In cases such as this, the hydraulic engineer has complete freedom to select the pump for best circuit operation.

• **Fluid Requirements**—A hydraulic engineer should not assume that his system will be operating on recommended hydraulic fluids. Most field operators prefer to run their hydraulic systems on engine lube oil to simplify supply problems. In the summer they use SAE 30 oil, and in cold weather, SAE 10 or 10W30, cut with kerosene. In the dead of winter, they may be using nearly all kerosene. Torque converter fluid or brake fluid is also used.

Fluid replacement between trips to the shop for scheduled overhaul depends on leakage rate. An operator in the field, miles from his base, with a low oil level will bring it up with anything available. A hydraulics engineer must be aware of these conditions and weigh them during the design stages of his system.

• **Determining Cost**—A major consideration in selecting a mobile pump is cost. A system must be thoroughly analyzed and a pump selected which will accomplish everything that needs to be done but no more. There is seldom justification for adding any frills into a circuit.

The class or type of application and the duty cycle enter into determining what type and quality of pump should be considered.

Many economic factors must be considered in selecting pumps. These are initial cost, installation cost, compatibility with other components, general usage in the field, quantity discount structure, manufacturer's reputation, replacement cost, and availability of service on the road or in the field. It may be more economical to buy a cheaper pump and throw it away at overhaul time, than to buy a more expensive pump and have to rebuild it. This requires careful consideration because the cheaper pump must be capable of required circuit performance, and the user must evaluate the circuit adequately.

As is readily apparent, the selection of a pump for mobile equipment service involves a broad spectrum of considerations, not all of which are strictly technical nor easy to evaluate. ▼▼▼

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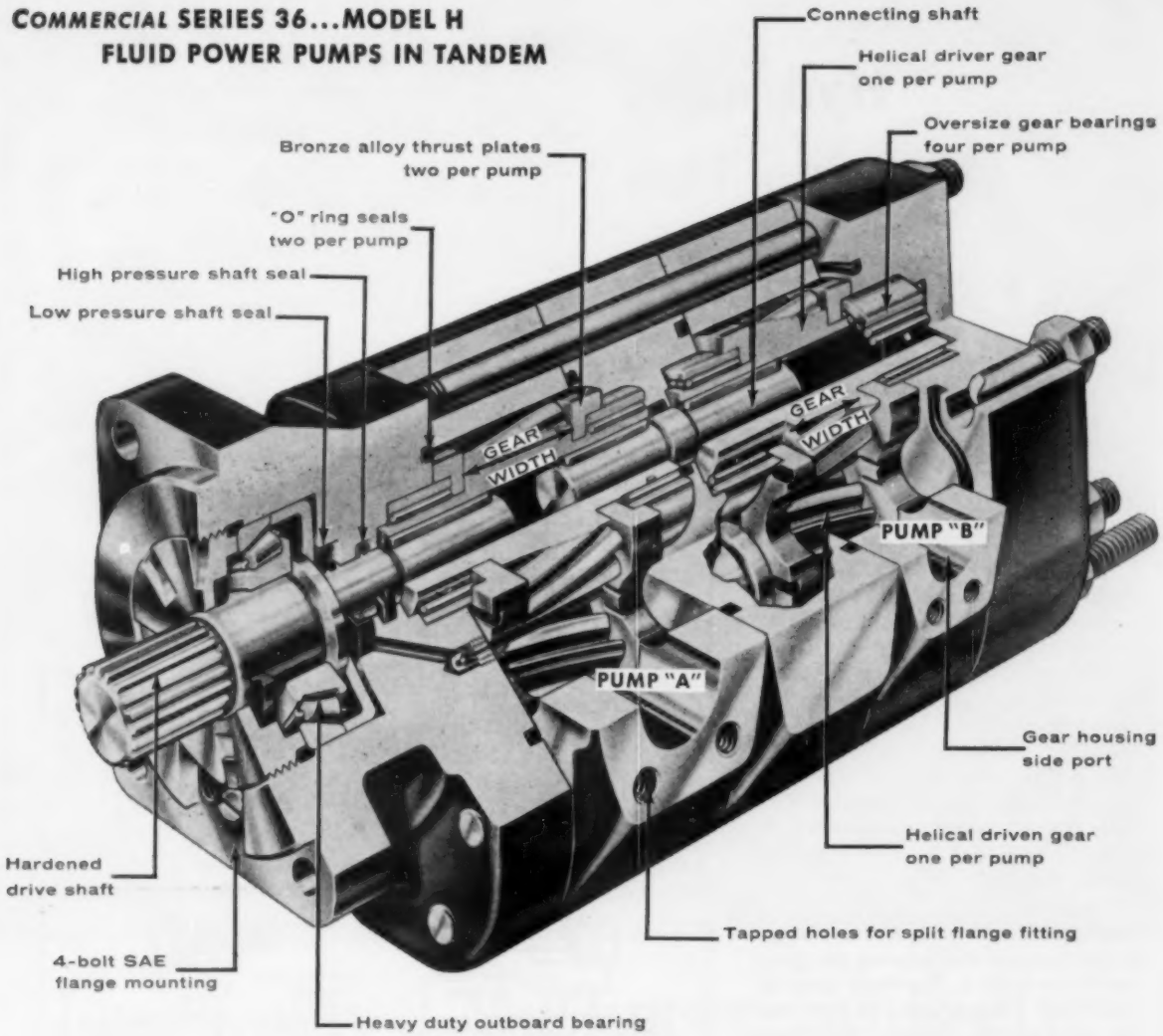
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Oversize gear bearings four per pump
Bronze alloy thrust plates two per pump
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GEAR WIDTH
GEAR WIDTH
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Hydraulic Service Tips

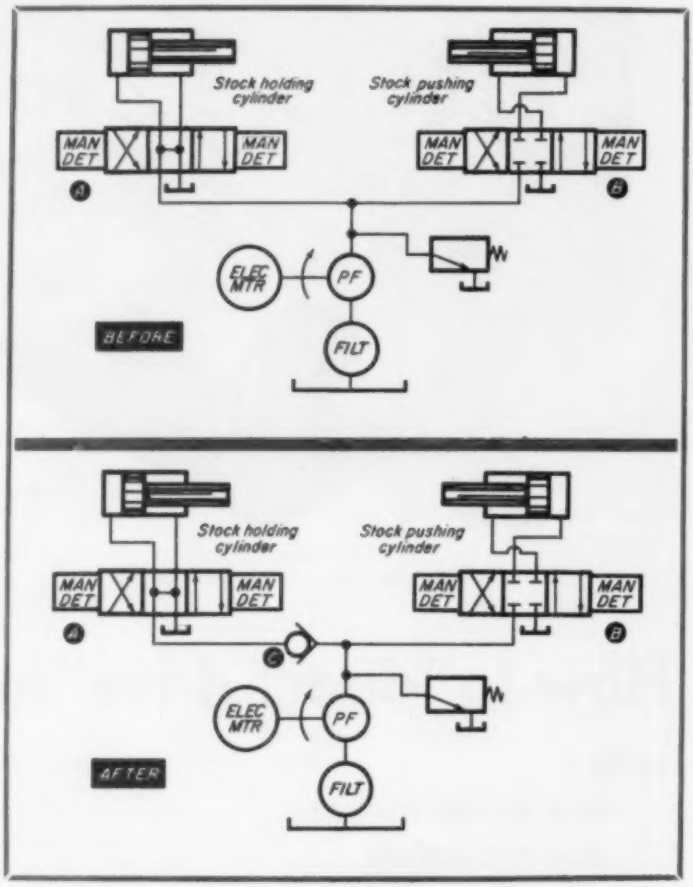
• By **G. C. BONNELL**, *Service Manager*
Machinery Hydraulics Division
Vickers, Incorporated, Detroit, Michigan

This is the first in a series of case histories based on actual service calls to repair hydraulic machines. Troubleshooting techniques and repair procedures explained in these articles will suggest ways to cut downtime in your plant.

1

Problem—On a machine which was converted to make lock-seamed tubing from flat stock, one pump supplies two hydraulic cylinders connected in parallel. Open-center valve *A* is actuated to extend the cylinder which holds the work on the mandrel. Closed-center valve *B* then actuates the cylinder which pushes the stock through the die. When valve *B* was actuated, pressure to valve *A* would drop, and the stock would fall off the mandrel.

Solution—Check valve *C* was installed in the pressure line between the pump and 4-way valve *A*. The check valve lets fluid flow through valve *A* to extend the stock-holding cylinder, but blocks any backflow when valve *B* is shifted to actuate the stock-pushing cylinder.



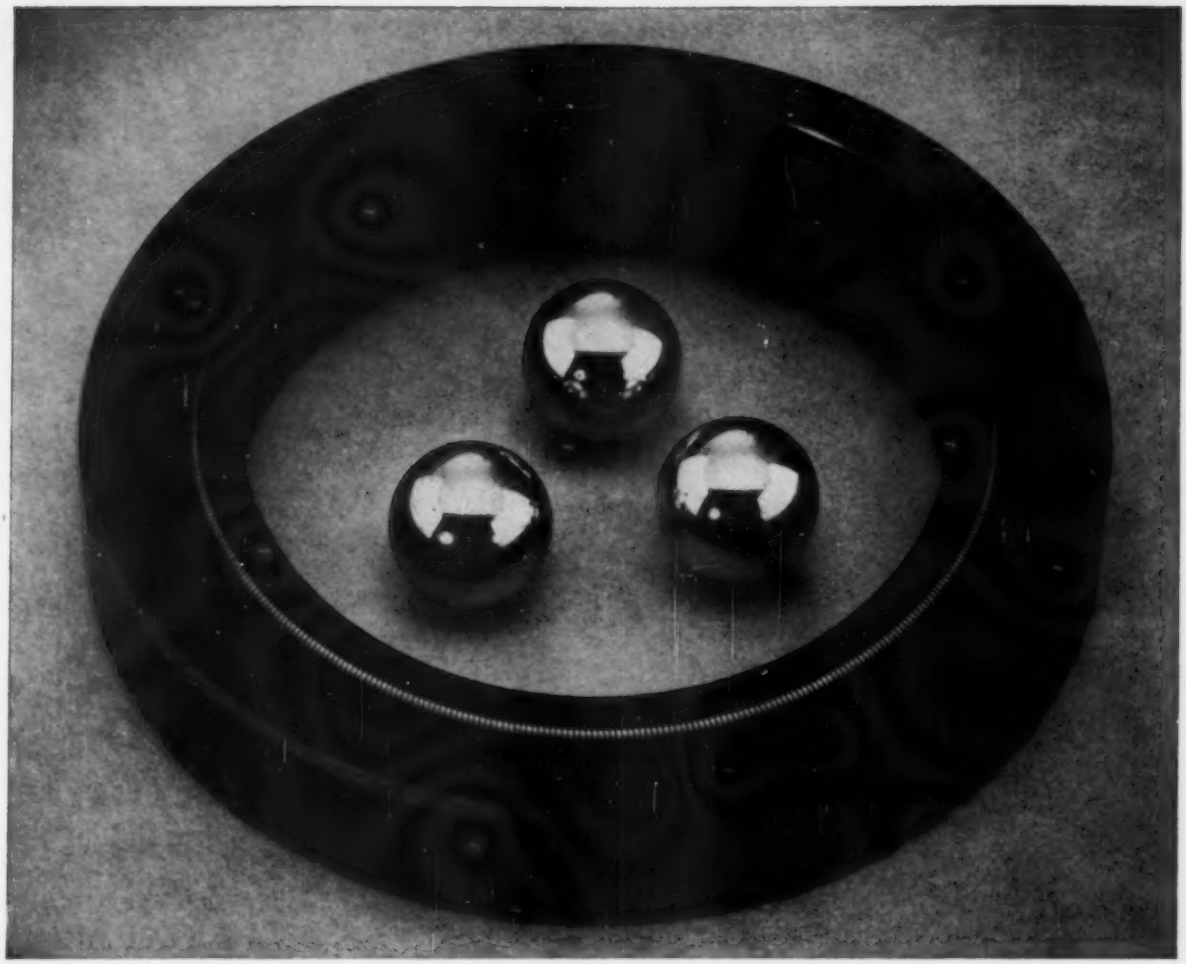
2

Problem—Complaints were received about repeated failures of a piston pump. This pump was mounted vertically, completely submerged in an oil reservoir, and driven at 870 rpm by a 50-hp motor. The serviceman noticed that the pump was noisy. When the oil-filler funnel was removed to check the oil level, half a pint of water was found in the funnel. Further inspection showed that the oil was badly aerated and did not have the right viscosity for that pump.

Solution—The following corrective measures eliminated further pump difficulties:

- Use of proper viscosity oil
- Installation of a large air filter on the tank to reduce condensation
- Installation of a tank baffle plate to separate return from intake oil.

▼▼▼



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ELECTROHYDRAULIC ANALOGIES . . . systems approach to fluid power design

• By **ROBERT E. RAYMOND,** *The R. E. Raymond Co., Zanesville, Ohio*

Part 4-USING THE COMPUTER

ELECTRONIC computers can be classified as digital or analog. Analog computers are more useful in general systems engineering and design, because they give a direct *electronic analog* or model from mathematical representations of the system under study. Variables are represented by computer voltages which are linked together according to system equations. The electronic model performs the same as the actual system.

The two main advantages of an analog computer over manual computations are:

(a) It handles any degree of non-linearity or complexity.

(b) It gives individual solutions instantaneously with numerous and frequent changes in the system parameters or equations.

Linear mathematical techniques can yield a general solution where a computer does not. But manually, non-linearities are often impossible or impractical to handle and particular solutions for every set of conditions are not practical.

With the computer, variables can be observed and recorded instantaneously for any solution. Both frequency response and transient response can be studied from the simulation set-up.

The analog computer is fast and can be speeded up or slowed down. It gives quantitative and qualitative results and a feel of system operation.

A digital computer is a purely numerical device which does not simulate continuous operation. All mathematical operations are carried out in programmed sequences. It has extreme accuracy, but gives no feel of the operation. Generally both types of computer can accomplish the same results.

• **Voltages Represent Variables**—As pointed out in Article 1, physical systems are fundamentally linked by work and power. Systems which are equivalent in *form* can be treated by analogy.

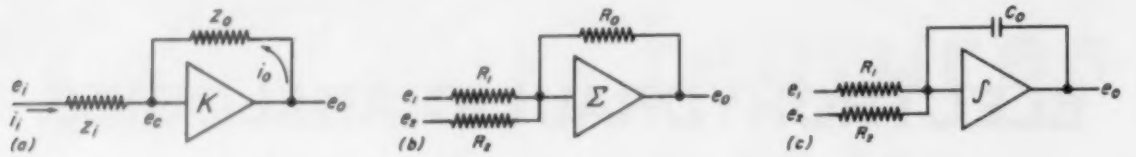
System effects such as resistance can be cataloged and cross-referenced between systems. Taking voltage analogous to pressure, and current analogous to flow maintains an equivalence of form. Resistance, capacitance, and inductance also have equivalent meanings between systems.

In the analog computer, all problem variables are assigned a voltage. Voltage is the only actual variable in the model and represents pressure, flow, distance, force, velocity, and other actual variables.

• **Develop System Equations**—To apply a computer, system operation must be expressed in integro-differential equations. Non-linearities can be included. Decisions about important effects must be made. Incremental variables to eliminate non-linear effects are not required.

Once system equations have been derived, it is necessary to choose computer amplifiers, integrators, and associated equipment, and to inter-connect these components according to the system equations.

Quantity scale factors must be determined so that computer voltage represents the variable under all conditions. A time scale factor must be selected to establish computer speed on the computer compared to the actual system time.



(a) Operational Amplifier Basic Amplifier Derivation

$e_c = \frac{e_o}{K}$ (Grid voltage)

$i_o = \frac{e_o - e_o/K}{Z_o}$ (Feedback current)

$i_i = \frac{e_i - e_o/K}{Z_i}$ (Input current)

$e_o = \frac{e_i}{(1\text{-}K)\ Z_i/KZ_o + 1/K}$

(General operational relation)

(b) Summation

$$e_o = -\left[\frac{R_o}{R_1}e_1 + \frac{R_o}{R_2}e_2 + 111111\right]$$

with $K >>> 1$

$e_o = -\frac{Z_o}{Z_i}e_i$

(General operational relation)

K = Basic Amplifier Gain

(c) Integration

$$e_o = -\int\left[\frac{1}{R_1C_o}e_1 + \frac{1}{R_2C_o}e_2 + 1111\right]dt$$

Z_i = Input Impedance

Z_o = Feedback Impedance

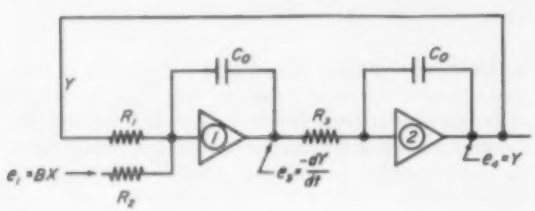
e_i = Input Voltage

e_o = Output Voltage

FIG. 1. COMPUTER CIRCUITS and mathematical operations performed.

• **Computer Elements**—The heart of an analog computer is the d-c amplifier. Circuits and operations of this component are shown in Fig. 1.

It can do addition, substraction, multiplication by constants, and integration. A number of separate input voltages can be added or subtracted and multiplied by constants by operational amplifiers. In (b) if $R_o/R_i = 1$ the input voltage is simply multiplied by −1. In (c) net input voltages are integrated as a function of time. Feedback impedance is a condenser. Time scale changes are handled by RC time constants of the integrator. Differentiation is not performed directly by an amplifier arrangement because of the amplitude peaks that would normally be present along with noise pick-up. Instead, a special technique is used. This is the key to effective operation of an analog computer.



Problem Equation $A\frac{d^2Y}{dt^2} = BX + Y$

Reduces to $\frac{dY}{dt} = \frac{1}{A}\int (BX + Y)\,dt$

FIG. 2. SOLVING EQUATIONS from highest derivative by successive integration.

Fig. 2 shows the concept of solving equations from the highest derivitive by successive integration. The procedure is to assure "Y" exists and is available to drive the first integrator as a part of:

$$A\frac{d^2Y}{dt^2}$$

This interrelation is true by the nature of the equation, but is difficult for laymen to comprehend.

Other mathematical operations such as multiplication of two variables, square roots, etc. are performed by "black box" electronic circuits or electromechanical arrangements specifically designed to generate the proper functions. These arbitrary, non-linear computing elements complete the necessary computer hardware.

The amount of computing equipment varies with the problem's complexity and the efficiency in setting it up. Various set-ups are usually possible requiring more or less hardware.

• **Setting Up the Problem**—A typical computer problem could be to study frequency response and other characteristics of the pressure reducing valve shown in Fig. 3.

Stability, transient pressure overshoot, and settling time with sudden changes in supply pressure would also be of interest.

The pressure reducing valve maintains pressure P_2 downstream from primary pressure source P_1. P_1 is a fast, high flow capacity source with relief valve control. The impedance at the downstream side of the valve is the capacitance of the oil and load, leakage of a bleed orifice, and the feedback path to the reducing valve.

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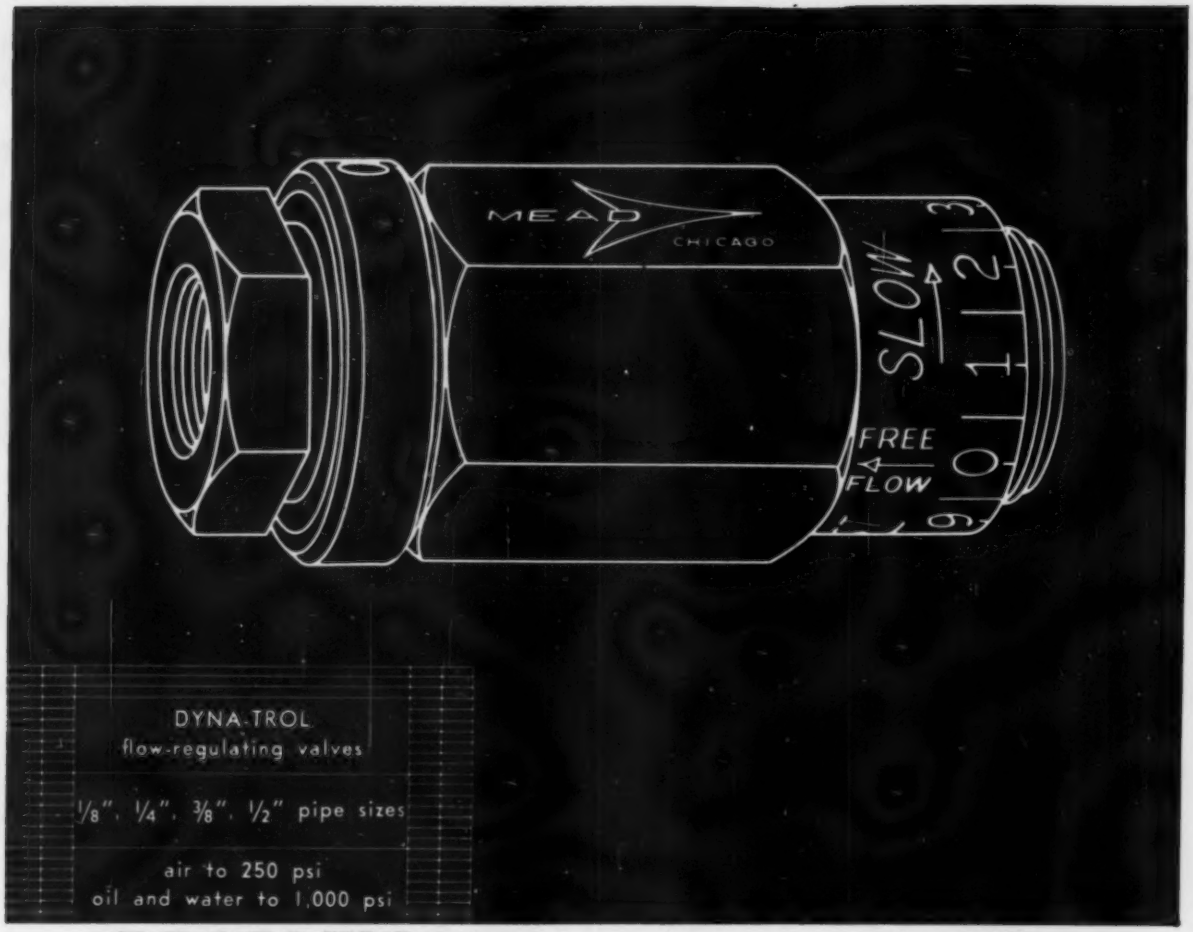

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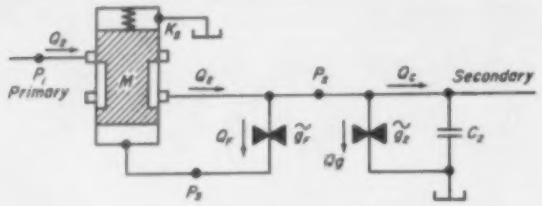

$Q_s = Q_r + Q_v + Q_c$
(Flow balance)

$Q_r = g_r\sqrt{P_2 - P_3}$
(Pilot flow)

$Q_v = g_v\sqrt{P_2}$ (Bleed flow)

$Q_c = C_s \frac{dP_2}{dt}$
(Compression flow)

$Q_s = g_v\,(b\text{-}X)\sqrt{P_1 - P_2}$
(Valve flow)

$P_2A_s = M\frac{dX^2}{dt^2} + K_v\frac{dX}{dt} + K_s\,(X_o - X)$
(Force balance)

P_1—Primary Pressure
P_2—Secondary Pressure
Q_T—Total Secondary Flow
Q_r—Spool Pilot Flow
Q_v—Leakage Flow
Q_c—Load Capacitance Flow
g_r—Damping Conductance Coefficient
g_v—Bleed Conductance Coefficient
C_s—Load Capacitance (oil)
M—Spool Mass
K_s—Spool Spring Rate
K_v—Spool Viscous Drag Coefficient
g_v—Valve Conductance Coefficient
b—Maximum Valve Opening
X—Valve Movement
X_o—Spring Precompression
A_s—Spool Pilot Area
L_s—Spool Inductance $\frac{M}{A_s^2}$
R_v—Spool Resistance $\frac{K_v}{A_s^2}$
C_s—Spool Capacitance $\frac{A_s^2}{K_s}$
P_o—Equivalent Bias Spring Pressure $= \frac{K_s X_o}{A_s^2}$
E_{bb}—Computer Voltage Source (represents b)

FIG. 3. FREQUENCY RESPONSE ANALYSIS of pressure reducing valve circuit.

The flow balance, rearranged for solution of P_2, is:

$$\frac{dP_2}{dt} = \frac{1}{C_s}\left(G_v\sqrt{P_1 - P_2} - Q_T - g_2\sqrt{P_2}\right) \quad (1)$$

The best procedure to follow with non-linear situations is to maintain flow form as nearly as possible. Therefore we can consider g_2 a *conductance coefficient* to the parabolic pressure term $\sqrt{P_2}$. Also, we can assign G_v as a non-linear conductance coefficient to a parabolic pressure term $\sqrt{P_1 - P_2}$.

$$G_v = g_v\,(b\text{-}X)$$

$$\text{where } X = \frac{1}{A}\int Q_T\,dt$$

In the limit, we can revert to a linear situation where small signals are employed and G_v is held constant, so that true conductance in³/sec/psi effect is present. By preserving the flow form, we are always treating the problem in the same way.

To complete the describing equations, we convert the force node of Figure 3 to flow form in terms of Q_T:

$$\frac{dQ_T}{dt} = \frac{1}{L_s}\left[P_s - R_vQ_T - \frac{1}{C_s}\int Q_T - P_o\right] \quad (2)$$

$$P_s = P_2 - \left(\frac{Q_T}{g_T}\right)^2 \quad (3)$$

• **Putting the Problem Into the Computer**—For good organization, we establish a primary computing channel for each unknown variable required for a solution. Each primary channel has summing amplifiers and integrators for that variable.

Secondary operations such as square roots, and multipliers are called *sub-routines* and are set-up separate from the primary channels.

Fig. 4 shows three primary channels with input and output variables. Pick-offs for sub-routines are taken from prime variables generated. This arrangement simplifies computations and maintains continuity.

Problem variables are shown in Figure 4; actually voltages would represent variables in the computer. Initially, it is helpful to use true variables in setting up channels. Input resistors and potentiometers are used to multiply variables by constants. Passive system effects on performance are easy to see. Merely changing input resistance to an operational amplifier changes system parameters.

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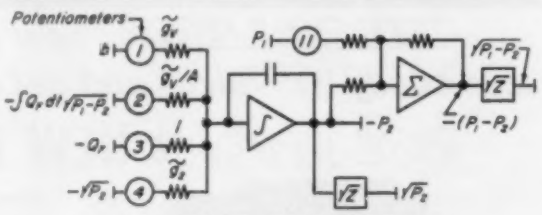
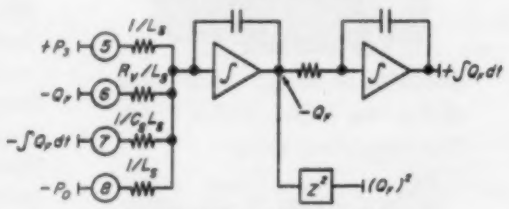
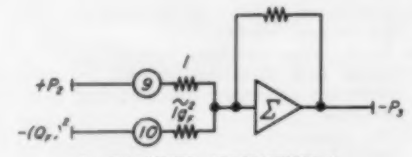


P_2 CHANNEL (EQUATION 1)



Q_T CHANNEL (EQUATION 2)



P_3 CHANNEL (EQUATION 3)

FIG. 4. PRIMARY COMPUTER CHANNELS for analysis of system in Fig. 3.

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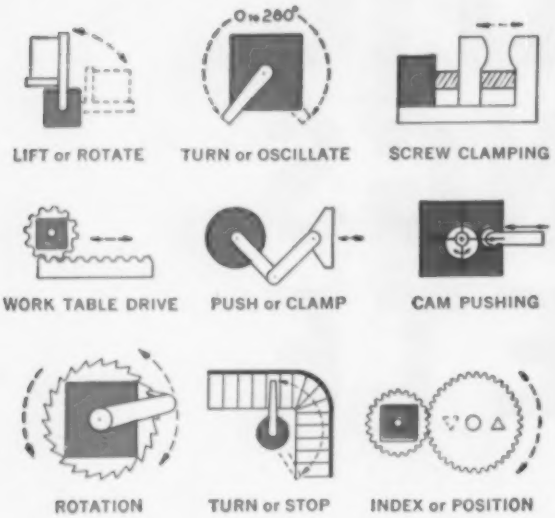

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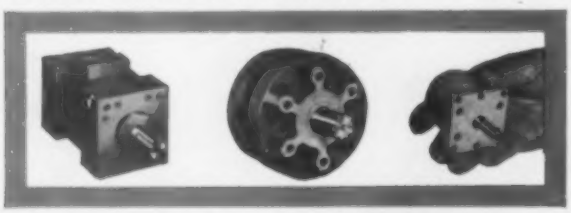

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ELECTROHYDRAULIC ANALOGIES

The computer can be set for initial conditions at the start of a particular solution. For example, if P_2 is at some steady state value at the instant P_1 changes, then C_2 must be already charged to simulate this. This is also true of spool position, quiescent flow rates, and other factors.

System equations are converted to the electronic model in programed steps. The model must always be in exact balance with the actual systems regarding units, basic scale factors, time scale factors, and machine electrical balancing factors.

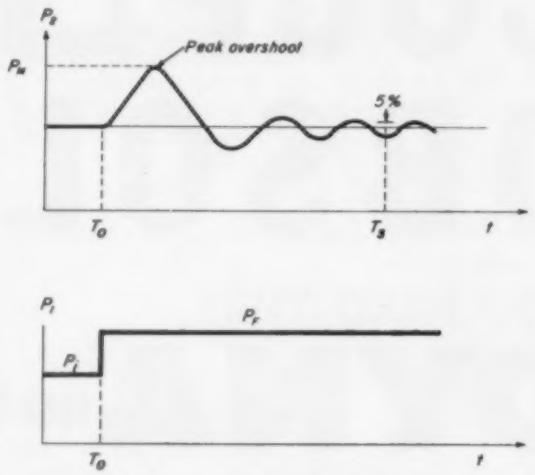

FIG. 5. EXAMPLE OF STEP CHANGE in P_1 creating a surge in P_2. P_M is result of sudden increase in P_1 from P_I to P_F. T_s is time required for P_2 to return to 5% of set pressure.

• **Transient Study**—Fig. 5 shows typical transient response. Varying g_F, C_2 or any other parameter shows effects on valve response. Initial conditions are set for $P_1 = P_I$. At the instant of computing, $P_1 = P_F$ (step change) and valve response is generated at the output of channel P_2. Operation can be repetitive to permit fast changes in system parameters and recorded effects.

The type of response can be estimated qualitatively and known points can be checked to support computer results. For example, shape of the response curve would be anticipated by the sequence of events in the particular problem. When the transient has decayed to steady state conditions, the steady state pressure, control flow, and spool position can be checked against calculations.

• **Computer as a Design Tool**—Preliminary design of a valve or other component can be done with simulations before actual models are made. Designs can be efficiently checked out.

Numerous system arrangements and their resulting effects on components can be readily investigated.

Similar response data would be almost impossible to get from an actual model and the effort would be very expensive. The computer is really a versatile test stand in permitting numerous system arrangements to be studied. ▼▼▼

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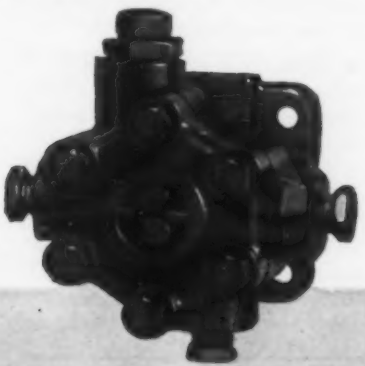

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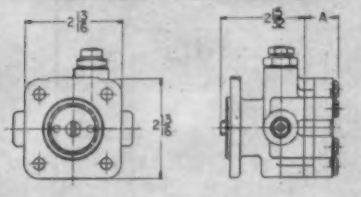

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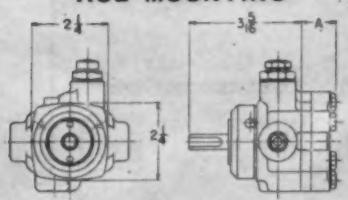
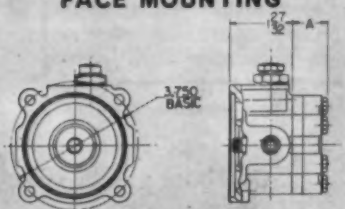
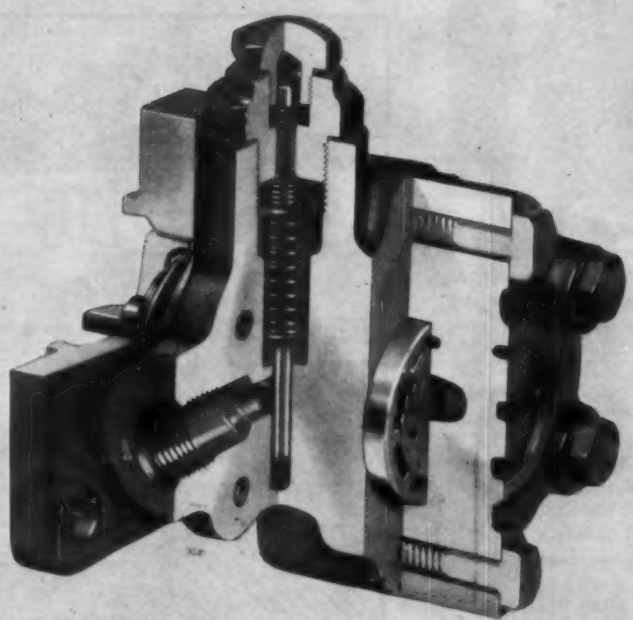
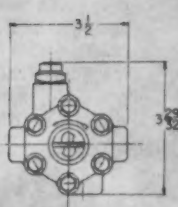


FACE MOUNTING





MODEL G



Model No.	Gear Width	"A" Dimension	Delivery at 1725 RPM OPSI	HP Req'd at 1725 RPM			
				40 PSI	80 PSI	200 PSI	600 PSI
G1	.180	15/16	12	.05	.06	.09	.22
G3	.280	1-1/32	20	.07	.08	.11	.26
G4	.340	1-3/32	24	.08	.10	.14	.32
G5	.437	1-3/16	31	.10	.12	.17	.40
G6	.562	1-5/16	40	.12	.14	.21	.53

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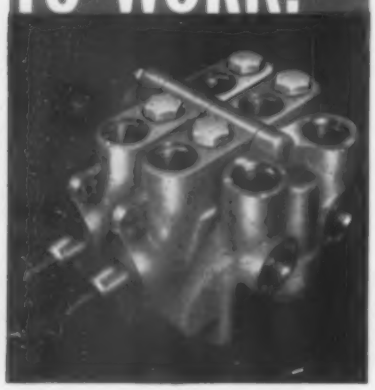

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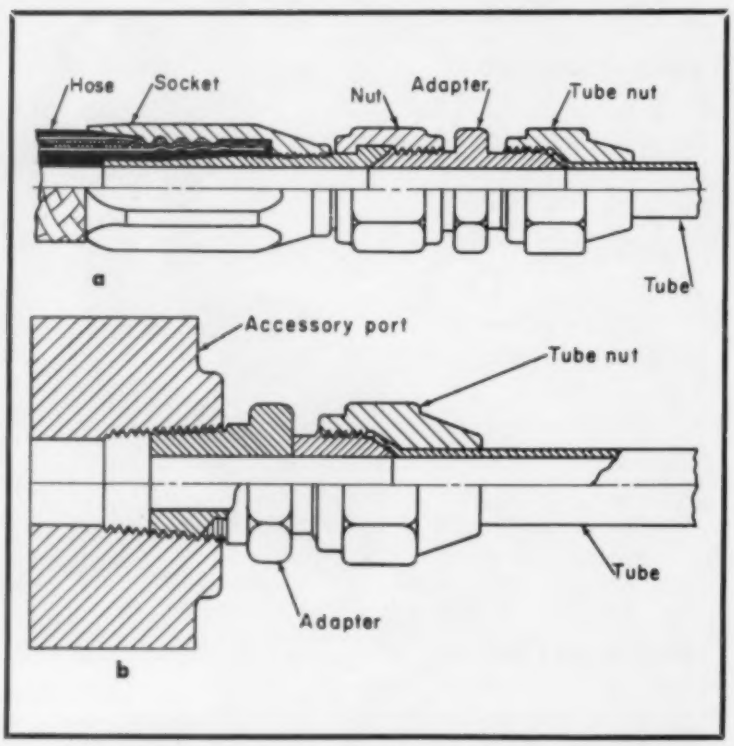
Understanding pipe, tubing,

• By **ROBERT G. COX**, *Manager, Engineering Service, Aeroquip Corp., Jackson, Mich.*

Improper line sizing can reduce hydraulic system efficiency. When plumbing a system with pipe, tubing, and hose, the designer must know their size designation systems. This article gives the relationship between tube, pipe, and hose sizes.

PIPE, tubing, and hose all have different size designation systems. Pipe is based on its inside diameter, tubing on its outside diameter, and hose is assigned dash numbers. Plumbing a hydraulic system often requires adapting from one type to another. Here is the relation between the size designations.

• **Pipe**—Nominal pipe size indicates the pipe's approximate inside diameter. However, the ID varies with the wall thickness and pressure rating of the pipe. The OD remains the same for any given size because pipe is threaded on its OD. As an example, a ½-inch standard weight pipe has an ID of .622 inch, and a ½-inch double



ADAPTER CONNECTS hose to tubing (a), and tubing to female ports (b).

and hose sizes

extra heavy pipe has an ID of .252 inch. Both have .840-inch OD.

• **Tubing**—Tubing sizes are based on their OD. This means that ½-inch tubing has a ½-inch OD regardless of its wall thickness. Tubing OD is held constant for different wall thicknesses to standardize on fittings.

• **Hose**—The accepted system for indicating hose sizes is with dash numbers (—4, —6, etc). The dash number is a nominal size in sixteenths of an inch, and indicates that the hose has an ID equal to the ID of that size tubing. Therefore, a —6 hose has the same ID as ⅜-in. tubing.

• **Port Fittings & Adapters**—An adapter is used to connect hose or tubing to female component ports. The illustration shows two arrangements for connecting to a component port, and connecting hose to tubing.

Tube connections are made by sliding a tube nut over the tubing and tightening it onto an adapter.

Hose ends are available with union nuts for direct connection to the same adapters as tubing.

• **Sizing Adapters**—To simplify the selection of adapters, pipe and tubing are also given dash numbers. Pipe dash numbers indicate the nominal pipe size in sixteenths of an inch, (—4 = ¼-in., —6 = ⅜-in. etc.) Dash numbers for tubing indicate the tube's OD in sixteenths of an inch.

Adapters are identified by a double dash number. The first dash number (following the part number of the adapter) gives the pipe thread size. The second dash number indicates the tube or hose size that can be connected to the adapter. This numbering system provides an easy method for identifying reducing fittings. ▼▼▼

DASH NUMBERS FOR TUBE, HOSE, & PIPE

Dash Number	Nominal Size—In. Pipe	Tube	Hose
— 2	⅛		
— 4	¼	¼	¼
— 5		5/16	5/16
— 6	⅜	⅜	⅜
— 8	½	½	½
—10		⅝	⅝
—12	¾	¾	¾
—16	1	1	1
—20	1¼	1¼	1¼
—24	1½	1½	1½
—32	2	2	2
—40	2½	2½	2½
—48	3	3	3

INSIDE DIAMETER OF PIPE—IN.

Nominal Size—in.	Pipe O.D.—in.	ID Standard Schedule 40—in.	ID Extra Heavy Schedule 80—in.	ID Double Extra Heavy—in.
⅛	.405	.269	.215	
¼	.540	.364	.302	
⅜	.675	.493	.423	
½	.840	.622	.546	.252
¾	1.050	.824	.742	.434
1	1.315	1.049	.957	.599
1¼	1.660	1.380	1.278	.896
1½	1.900	1.610	1.500	1.100
2	2.375	2.067	1.939	1.503
2½	2.875	2.469	2.323	1.771
3	3.500	3.068	2.900	

INSIDE DIAMETER OF TUBING—IN.

Nominal Size—in.	Wall Thickness—In. .035	.042	.049	.058	.065	.072	.083	.095	.109	.120
⅛	.055									
5/16	.1175									
¼	.180	.166	.152	.134	.120					
5/16	.2425	.2285	.2145	.1965	.1825					
⅜	.305	.291	.277	.259	.245					
½	.430	.416	.402	.384	.370	.356	.334			
⅝	.555	.541	.527	.509	.495	.481	.459	.435		
¾			.652	.634	.620	.606	.584	.560	.532	
⅞			.777	.759	.745	.731	.709	.685	.657	
1			.902	.884	.870	.856	.834	.810	.782	.760
1¼			1.152	1.134	1.120	1.106	1.084	1.060	1.032	1.010
1½					1.370	1.356	1.334	1.310	1.282	1.260
1¾					1.620	1.606	1.584	1.560	1.532	1.510
2					1.870	1.856	1.834	1.810	1.782	1.760

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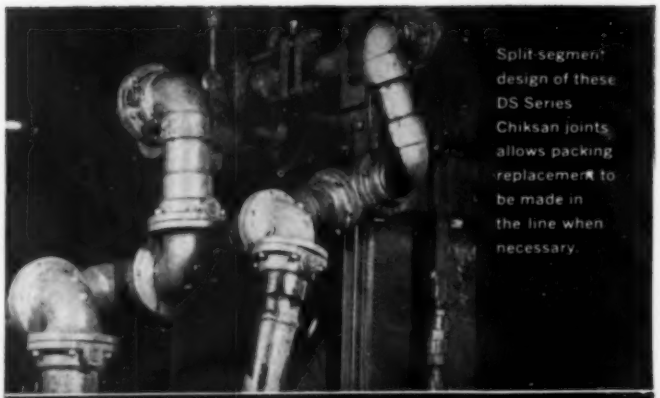
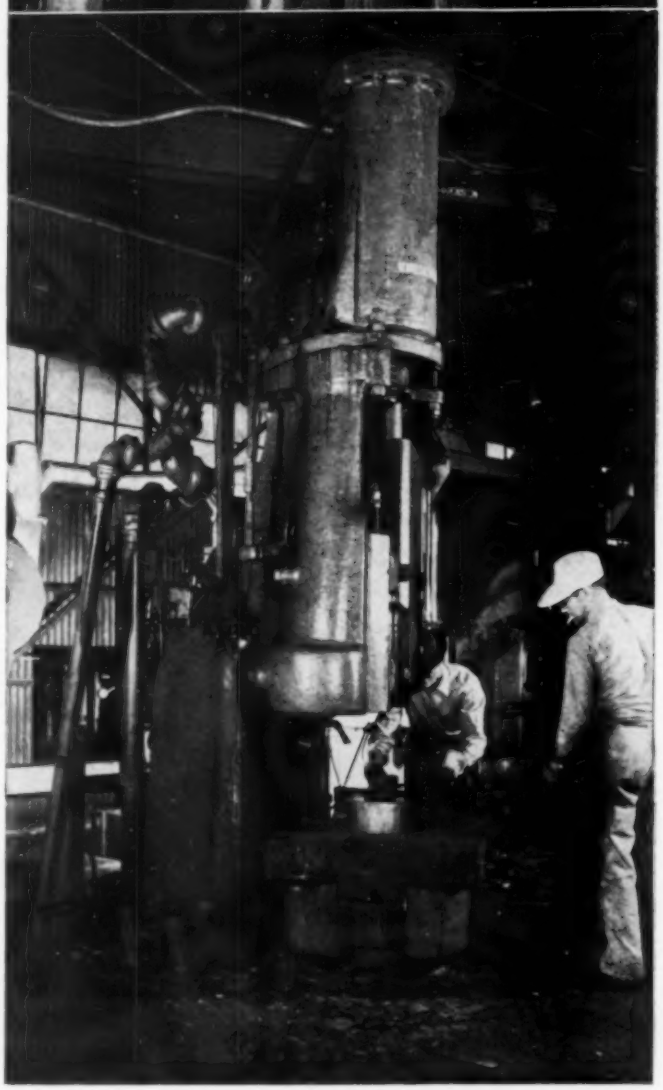


Split-segment design of these DS Series Chiksan joints allows packing replacement to be made in the line when necessary.



SHOCK, HIGH PRESSURE STEAM DOESN'T FAZE THESE CHIKSAN JOINTS—A 2000 pound dropforge with high pressure steam sets up a rough set of service conditions. These Chiksan swivel joints replaced flexible metal tubing which was going out in two and three weeks. Joints have been in service for over five months and customer reports good service to date, expects years more.

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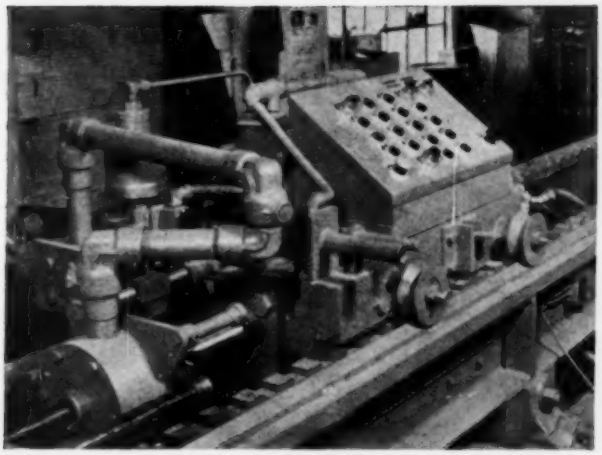
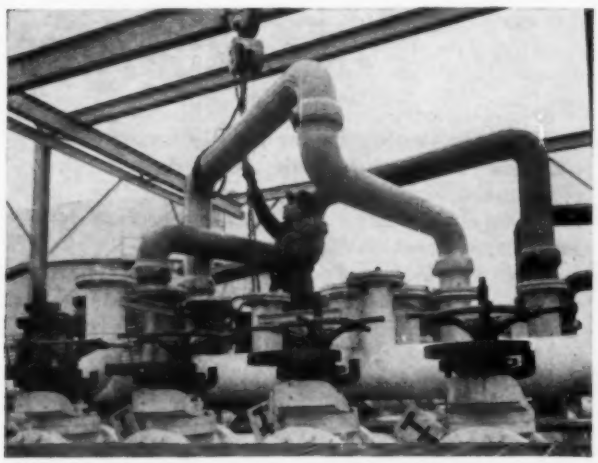
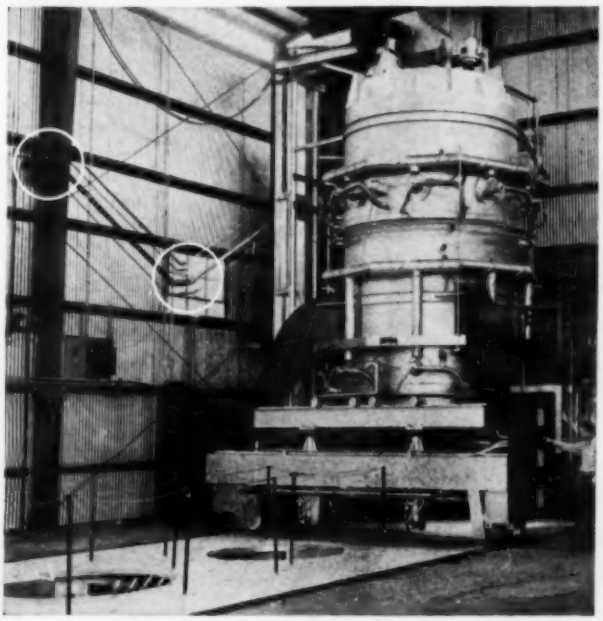


RUPTURE PROOF LINES FOR HIGH PRESSURE HYDROTESTING—Critical lines take on a new measure of safety with these flexible steel swivel joints. In service on a pipe testing machine, these lines receive up to 1000 pounds of pressure and more every five seconds as lengths of new pipe move through the testing machine. Only occasional service is required to keep these joints in top working condition.

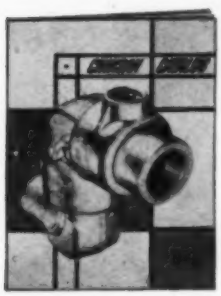


SWIVEL JOINTED JUMPER SYSTEM SOLVES MANIFOLD PROBLEMS—Moving large quantities of differing liquids from barge to storage tanks posed a problem. A closed system wasn't practical because of contamination due to leakage or accidental opening of a valve. Use of a Chiksan swivel jointed jumper system provided a solution that eliminated cross contamination.



CONSTANT FLOW CHARACTERISTICS ALLOW PRECISE CONTROL—Heat treating furnaces require exacting temperature control. Previous experience with flexible hose indicated too much variation in flow characteristics. By using swivel joints and metal piping, company engineers were able to design a supply line system that insured desired control.

#60-54



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Dynamic testing of electrohydraulic made simpler

• By RICHARD E. OSGOOD*, *Research Engineer, Boeing Airplane Co., Seattle, Wash.*

DYNAMIC characteristics of an electrohydraulic valve are needed to design high response hydraulic servo systems. The dynamic response test technique, commonly used to check flow control servovalves, requires linear or rotary actuators with position and (or) velocity transducers to hold the actuator centered and to monitor the valve output. This actuator-type dynamic response measurement has the following disadvantages:

(1) Only *no-load* dynamic characteristics are measured. Dynamic characteristics under *load* conditions, generally provide a more realistic picture of how a servovalve will behave in a servo system.

(2) Special equipment (actuator, position, and velocity transducers) is necessary. Trained personnel are required to operate this equipment.

(3) Laboratory tests using actuator systems show that the sliding friction and vibration in such tests cause rapid wear. This causes unknown loading and damping conditions, periodic replacement of expensive equipment, and possible downtime.

• **Dynamic Testing Under Load**—The simplified technique to measure dynamic characteristics of electrohydraulic servovalves eliminates the need for actuators to record output, and provides response data for maximum load conditions.

The new method measures output in terms of valve slide motion. The slide output motion is recorded with pressure transducers connected to the valve load cylinder ports, (Figure 1). Though the valve input signal is a sine wave, the valve output (with blocked cylinder ports) is a square wave. The reason for the change from a sine to a square wave is noted from the blocked load port differential pressure wave, (Figure 2).

Here is how the valve slide motion is monitored, using pressure transducers.

Using a d-c balance unit (Figures 1 and 3), one of the load differential pressure peaks is adjusted to zero on the oscilloscope. The d-c input current is noted. The opposite pressure peak is then moved to the zero pressure point on the oscilloscope (Figure 4). Again the d-c input current is recorded. The peak-to-peak slide motion (in equivalent input current) is found by adding the two d-c input current readings. The amplitude ratio of a servovalve output to input (at various oscillator driving frequencies) is equal to the peak-to-peak slide motion of d-c current over the peak-to-peak input current applied to the valve.

ADVANTAGES OF THE DYNAMIC TESTING METHOD

- Eliminates unknown loading or damping caused by sliding friction.
- Eliminates inertia load variations—except for fluid trapped between servovalve ports.
- Wide frequency range capabilities approach zero frequency.
- Improves accuracy at high and low frequency.
- Simplifies procedure and requires only standard laboratory equipment.
- Does not require a closed loop system to prevent drift. In a closed loop system valve response varies with feedback gain and input amplitude.
- Does not require special attachments or servovalve changes.
- The amplitude ratio can be referenced to zero frequency. (The input current of any frequency is equal in amplitude to the output reading at zero frequency).
- This technique can isolate mechanical problems affecting electrohydraulic servovalve output due to vibration sensitivity.

**Mr. R. E. Osgood has passed away since this article was submitted for publication in* HYDRAULICS & PNEUMATICS *magazine.*

servovalves and more accurate

The phase relationship of valve output to input can be measured by adjusting the d-c input current to the valve null, and comparing the square wave pressure output with the sine wave input. This is done on an oscilloscope with a Lissajous pattern (Figure 5).

The sinusoidal wave input signal is applied to the oscilloscope horizontal amplifier and the square wave from the pressure transducers to the vertical amplifier. The square wave is identical to its fundamental (a sine wave) at the point of zero differential pressure or where the square wave crosses the horizontal axis. The phase angle measurement must be taken between these points for the Lissajous analysis to hold true. The distance between the points, where the Lissajous figure crosses the vertical axis, has no meaning because of the square wave output signal.

Improved accuracy is obtained when a square wave and a sine wave are compared because the two opposite sides of the Lissajous pattern cross the axis, or line, or phase measurement at almost a right angle. Any drift in the oscilloscope, or shift in the valve output, can introduce only small errors during the data recording process.

A commercial phase meter may be used in place of an oscilloscope for phase lag measurements. It gives direct recordings in degrees, and eliminates calculations and eye strain in reading an oscilloscope. If many frequency response tests are planned, a phase meter will be useful.

• **Evaluation of the Test Technique**—Results of a servovalve frequency response test performed with this new technique, are compared to tests run with the actuator system (Figure 6). The difference in response, particularly at the low frequencies, can be explained by the following inherent differences:

(1) Flow reaction forces affect the slide position in the actuator method. In the blocked port technique, the test valve has essentially no flow reaction forces at the low frequencies. The flow reaction forces increase, however, with the frequency, depending on compliance in the cylinder ports.

(2) The actuator method requires a closed loop system to prevent the actuator from striking the ends at low frequencies, and to provide automatic balance at high frequencies. The new technique allows the servovalve to operate open loop, thus eliminating the problem of variable system parameters affecting valve frequency response.

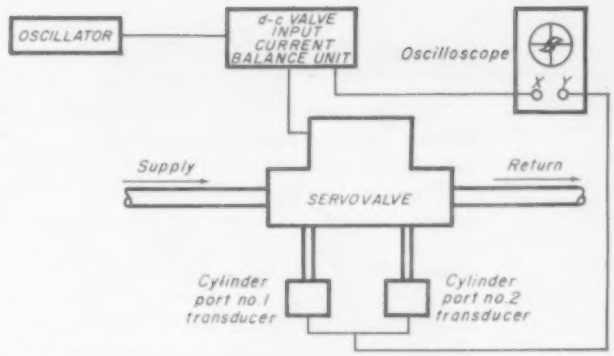

FIG. 1. Frequency response test circuit.

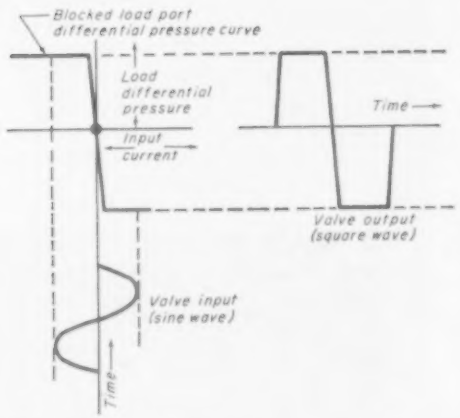

FIG. 2. Relationship of valve input sine wave to valve output square wave.

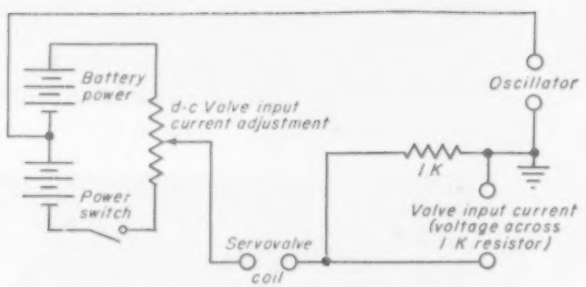

FIG. 3. Balance unit—d-c valve input current.

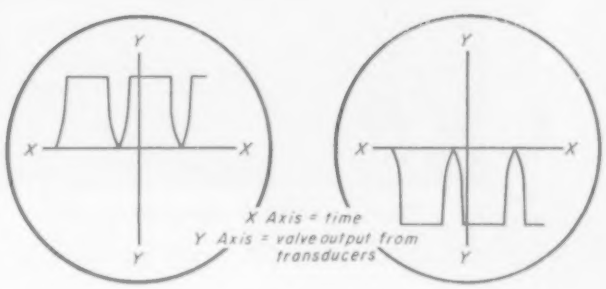

FIG. 4. Adjustment of pressure peaks to zero pressures.

This new method yields accurate frequency characteristics at low amplitude input signals, or near the null region, where the valve operates most of the time.

Since the blocked port method of measuring frequency involves an amplitude measurement on each side of center, the non-symmetrical valve dynamic characteristics can be studied. Figure 7 shows the dynamic response of a non-symmetrical valve. Note that the slide has a lower cut-off frequency on one side of null than on the other. Tests on symmetrical valve designs show identical cut-off frequencies on both sides of center.

Figure 8 shows a comparison of frequency responses when the pressure transducers are mounted close to the valve pressure ports, and when a foot of ¼ in. OD tubing is used to connect the transducers to the valve ports. Compliance between the valve ports reduces the response characteristics accordingly. Therefore, to obtain an accurate representation of the servovalve frequency response, high-response-low-volume displacement pressure transducers should be used and connected very close to the servovalve pressure ports.

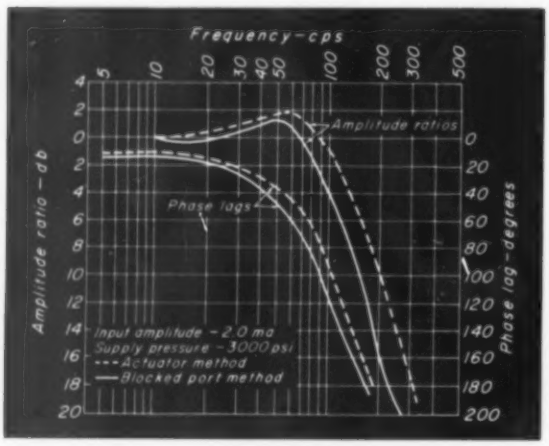

FIG. 6. Servovalve frequency response results.

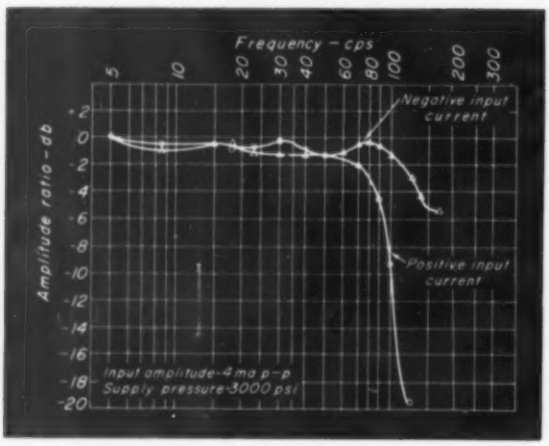

FIG. 7. Frequency response of unsymmetrical valve.

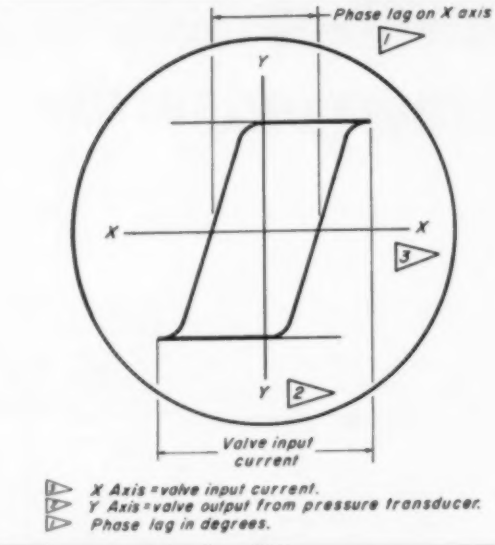

FIG. 5. Lissajous pattern.

An investigation of electrohydraulic servo system mechanical stiffness, shows that the valve response technique may also be used to locate problem areas. Backlash and spring rates including fluid compliance, can be isolated by observing the frequency response as different sections of the system are mechanically locked out.

This test technique (with slight modifications) has been used successfully to observe servovalve vibration sensitivity. The valve output can be monitored in the same manner as in the frequency response test. Instead of the oscillator driving the valve, and creating an output, the servovalve is placed in a vibration environment which provides a driving signal to the valve. Any output noted is an indication of the valve vibration sensitivity. The peak-to-peak motion on the slide can be measured in terms of equivalent input current required to give the same motion as produced by the vibration environment. ▼▼▼

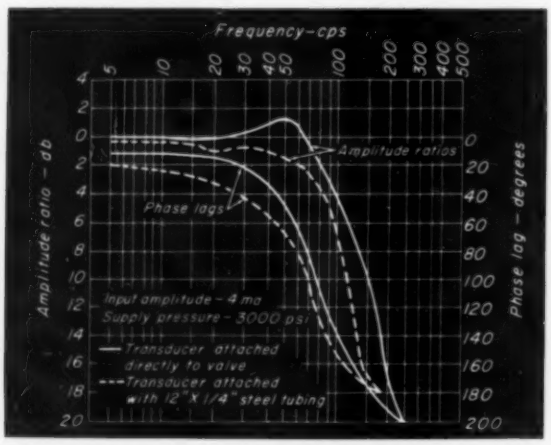
Frequency – cps
Amplitude ratios
Phase lags
Amplitude ratio – db
Phase lag – degrees
Input amplitude – 4 ma
Supply pressure – 3000 psi
Transducer attached directly to valve
Transducer attached with 12" x 1/4" steel tubing

FIG. 8. Compliance effects on valve blocked port frequency response.

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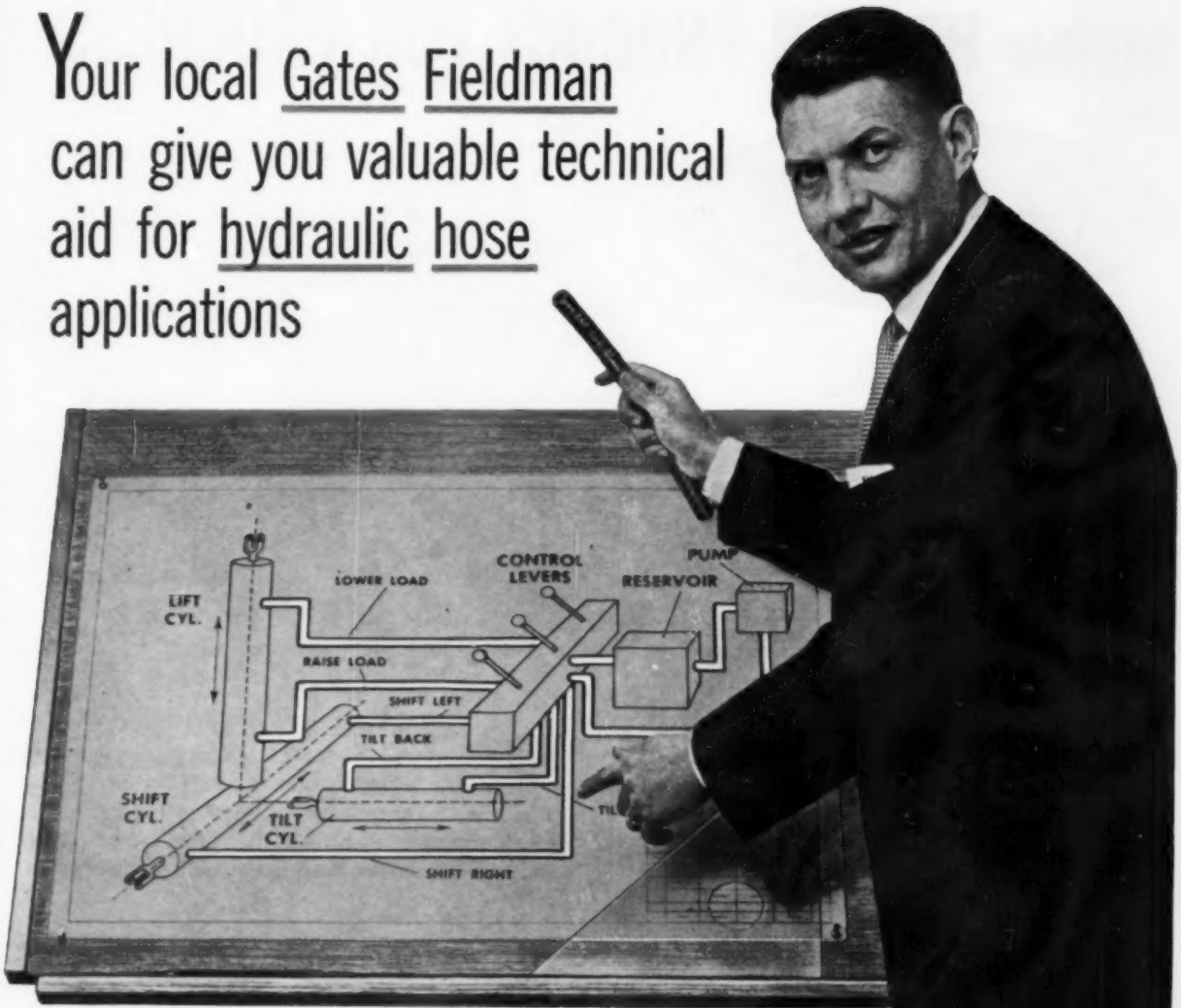

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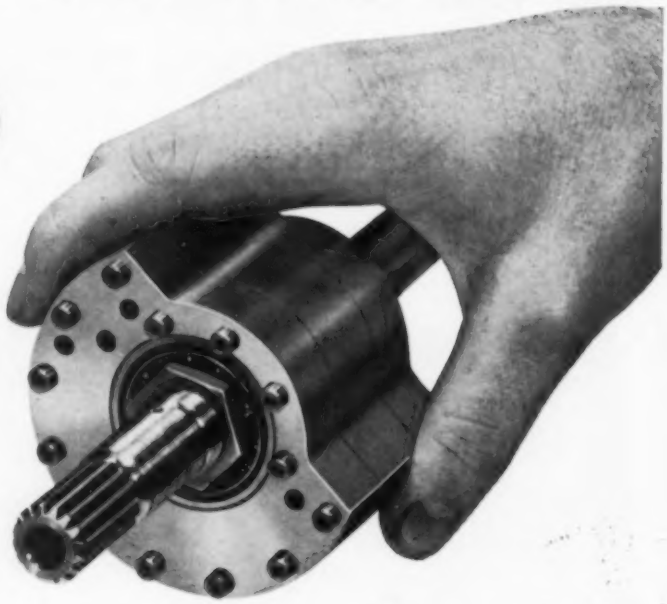

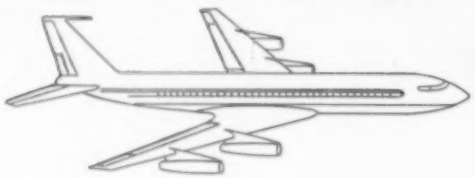

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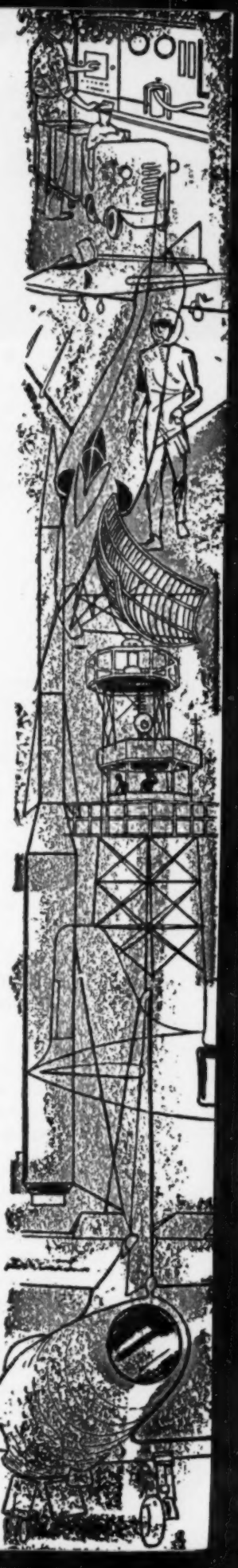

Pneumatics to Operate Flight Control Surfaces

An Air Research and Development Command contract for design, development, and testing of a pneumatic system for operating flight control surfaces of supersonic aircraft and missiles has been awarded to Convair Division of General Dynamics Corp. The high temperature system will be nuclear radiation resistant. Such a system would replace present hydraulic systems for temperature above 1000 F. The half-million dollar, two-year contract will be performed for WADD by Convair-San Diego.

Rocket Society's Space Report

"Space Flight Report To The Nation" is title of the 16th annual meeting of the American Rocket Society at the New York Coliseum, October 9-15th. The meeting will be a combination of technical sessions and an exposition. Over 200 papers will be presented in 45 sessions including Power System, Missiles & Space Vehicles, Guidance & Control, Propellants & Combusion, and Test, Operation, & Support.

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Bendix Plans Cryogenic Lab in Iowa

A laboratory for applied research and development of cryogenic products will be built at Davenport, Iowa, by the Pioneer-Central division of The Bendix Corporation. Dr. Thomas Flynn will direct the activities of the laboratory, to be known as the Cryogenic Development Laboratory. It will be particularly involved with applications of liquid hydrogen, and will be operated together with a liquid oxygen research facility that Bendix has maintained for nearly 18 years.

Hydraulic Shock Absorbers for Minuteman Silos

Hanna Engineering Works has been awarded a contract to build high impact, hydraulic shock absorbers for the Minuteman missile program. Hanna designed these special shock absorbers specifically for the blast-valve assembly in underground silos.

Sundstrand to Develop Dyna-Soar Power System

Sundstrand Aviation, Denver, recently received a multi-million dollar sub-contract for the development of the power generation system for Boeing's Dyna-Soar manned space glider. The contract is the result of several years of company and government funded research in the fields of space power, undersea propulsion, aircraft accessories, and fluid transmission systems.

Designing for safety— 880's landing gear

• By **ROBERT A. COX,** *Design Engineer,*
Convair-San Diego Division of General Dynamics Corp., San Diego, Calif.

Floating pistons, a 6-way, 3-position valve, a 3-line system, and oil-or-air door actuation are hydraulic features of the 880's main landing gear. This description shows how the system has been designed for reliable and fail-safe operation

EACH COMPONENT in the Convair 880's main landing gear hydraulic system contributes to reliability. The main landing gear control lever in the 880's cockpit operates the landing gear position selector valve through a cable control system. The landing gear control has up, neutral, and down positions which correspond to the three positions of the position selector valve. Also, there is an emergency gear lever in the cockpit, which lowers the landing gear if the normal system fails. The emergency gear lever operates the position selector and emergency valves, and releases the door uplocks and landing gear uplocks.

• **Emergency Valve Vents System**—The landing gear position selector valve contains two spools and sleeves. The landing gear control lever operates one spool, which ports pressure for gear up or down or relieves pressure from the entire circuit in neutral position. The emergency spool normally has no effect on valve operation. When the emergency spool is operated, it connects the system to tank through the *V* port.

The gear valve is a 5-way, 2-position spool valve and is mechanically actuated when the doors are operated. When the door is fully opened, the valve is actuated. When the doors start to close, the valve returns to its normal position. This relieves pressure from the main landing gear cylinder as soon as the doors start to close and prevents pressure from being applied to the gear cylinder before the doors are fully opened.

The door valve is a 6-way, 3-position, spring-centered valve of spool and sleeve construction. It is shifted by the gear uplock or downlock mechanism, and is centered when neither the uplock nor downlock are engaged.

• **Floating Pistons Reduce Force**—The double-acting, main landing gear cylinder contains a snubbing chamber which is effective at the end of the retraction stroke. The piston floats on the rod, so when the cylinder is fully extended (gear down) pressure is only applied against the rod area. However, during extension or re-

CONVAIR JETLINER during take-off. The main landing gear retracts inboard. The wheel well doors are normally closed, and are only open when the landing gear is in motion. The decision to have the wheel well doors closed when the plane is on the ground (gear down) was made in the early design stages of the 880. This protects equipment in the wheel well during take-off and landing roll.

traction pressure is applied to the full piston area.

Each of the two wheel-well doors is operated by two cylinders. Each door cylinder contains an integral shuttle valve to permit using high pressure air for opening the doors in an emergency.

The uplock and downlock on each gear is hydraulically operated. The single-acting downlock cylinder is hydraulically operated for downlock release. It is spring-loaded for down lock engagement, so that the gear will lock down without hydraulic pressure. This permits gear locking on free-fall.

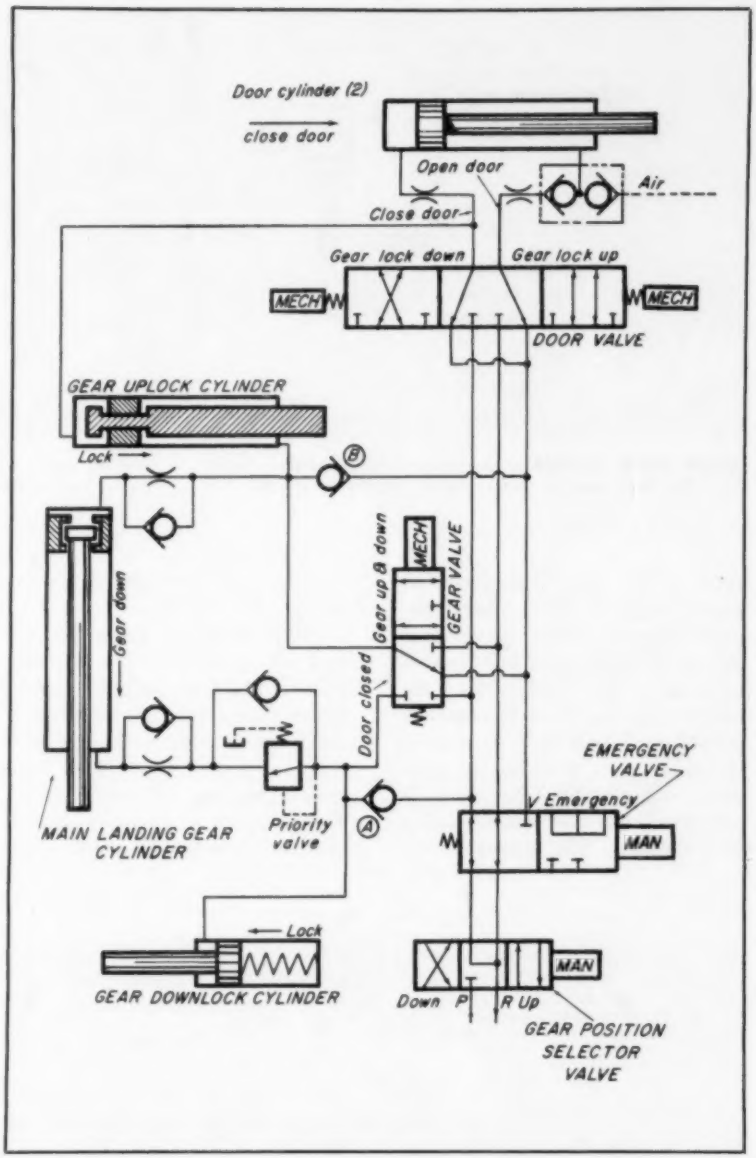
The double-acting, uplock cylinder has a floating piston similar to the main gear cylinder. This reduces the effective area and force at both ends of the stroke.

• **Restrictors Control Speed**—Fixed restrictors control door operating speed, and limit impact forces during door opening and closing. Also there are one-way restrictors in the both lines to the landing gear cylinder. During landing gear extension, external forces act in the same direction as the hydraulic forces. Restricting flow into and out of the cylinder reduces cylinder velocity and impact forces.

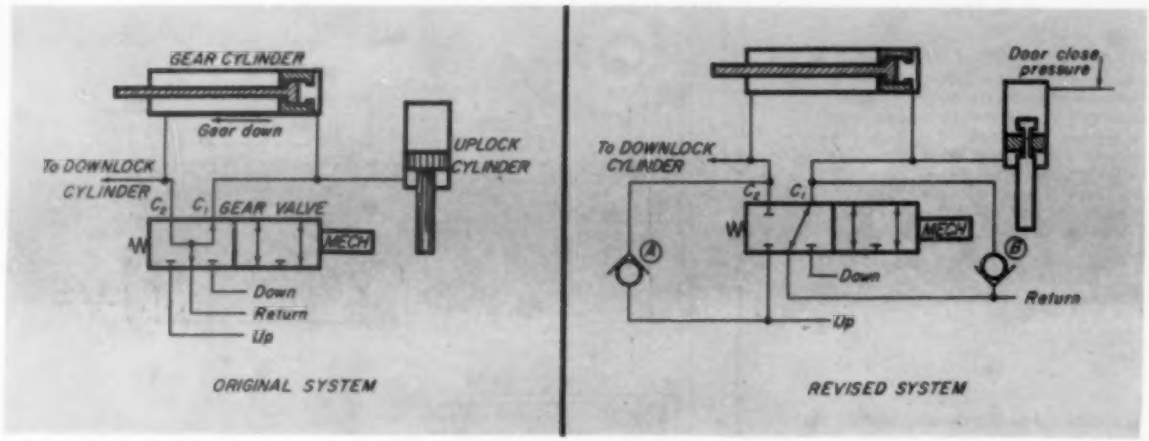
Release of the downlock is pressure sequenced with the main landing gear operation by using a balanced outlet, priority valve. It is set at 1100-psi cracking pressure and assures that the downlock is released before pressure is applied to the gear cylinder.

• **Landing Gear Retraction**—A complete cycle of the landing gear starts with the main landing gear down and locked, wheel well doors closed, the position selector valve in the down position, and the door valve in the gear-locked-down position. Gear up is selected. This operates the selector valve to the up position. The gear valve is in the door-closed, normal position, preventing pressure from being applied to the gear cylinder. First the wheel well doors open when the door cylinders retract. The doors actuate the gear valve when the doors are fully opened. Pressure through the gear valve is applied first to the downlock cylinder, releasing the downlock. The downlock release allows the spring-centered door valve to return to center position. This removes pressure from the door cylinders.

When pressure in the gear-up line reaches 1100 psi, the priority valve opens and the gear cylinder



MAIN LANDING GEAR CIRCUIT between the door valve and the gear position selector valve is a 3-line system. This return line connects directly to tank so that hydraulic lock will not occur in the gear and door cylinders. The line allows free fall of the landing gear in case of hydraulic system failure.

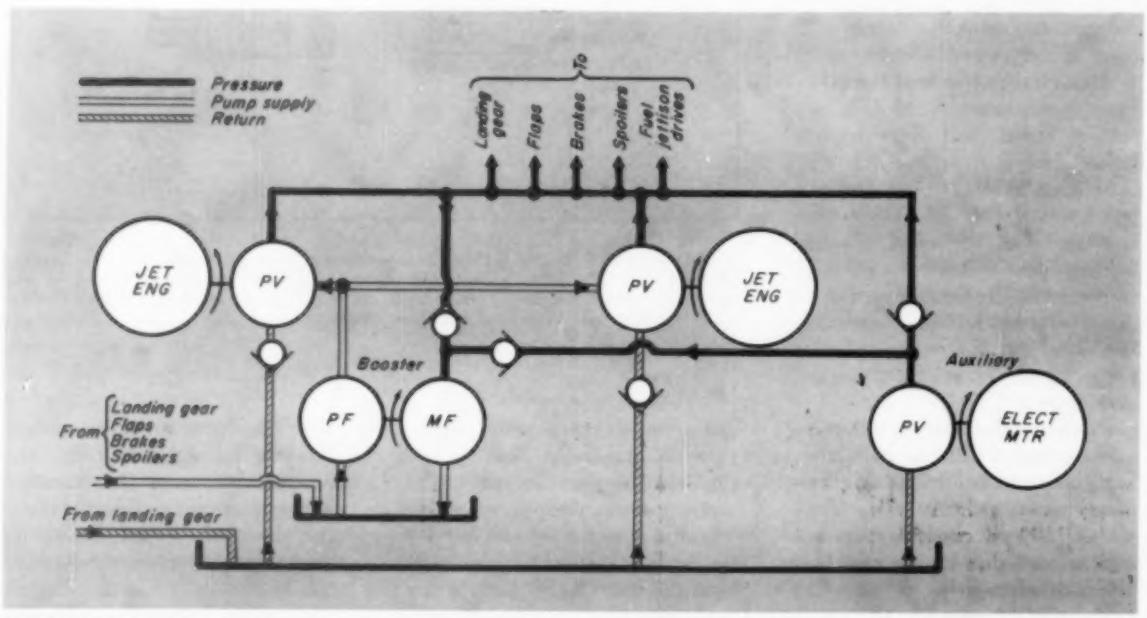


AFTER GEAR LOCKUP in the original system, pressure surge from the main landing gear cylinder sometimes unlocked the landing gear. In the revised system this is prevented by not connecting port C_2 to C_1.

retracts the gear. The retracted gear actuates the door valve to the gear lockup position. This closes the wheel well doors and applies pressure to the head end of the uplock cylinder, insuring complete actuation of the uplock. As soon as the doors start to close, the gear valve is deactuated. This removes pressure from the main landing gear cylinder. The gear-up cycle is completed when the doors are closed and locked.

The door uplocks are mechanical and are operated by the final motion of the door cylinders as the doors close. Then the pilot moves the position selector valve to neutral, removing all pressure from the landing gear hydraulic system. Extension of the landing gear is just the reverse of the retraction cycle. Total cycle time is 10 seconds. Doors open, 2 seconds; gear extend and lock, 6 seconds; and doors close, 2 seconds.

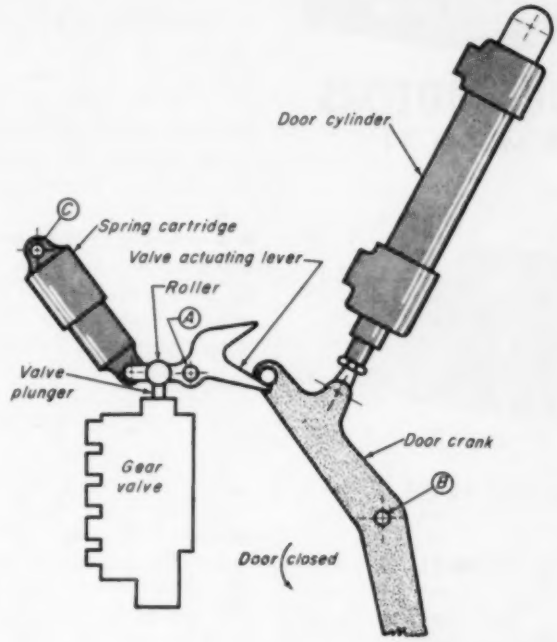
The landing gear-up or down cycle, is reversible. Thus, any time during the up cycle, gear-down can be selected, and any time during the down cycle, gear-up can be selected. This is why the gear cylinder is not pressurized during



HYDRAULIC POWER for the main landing gear and main landing gear doors is supplied by one of the plane's two hydraulic systems. This system also powers the flaps, main wheel brakes, spoilers, and fuel jettison pump drives. The hydraulic system is a 3000-psi, closed center type. Power is supplied by two, variable delivery pumps, each driven by one of the right engines. A boost pump driven by a hydraulic motor maintains pump inlet pressure. In addition to the engine driven pumps, an electric motor driven, auxiliary pump provides power for ground operation and power to drive the boost pump during starts.

MAIN LANDING GEAR FAIRING is attached directly to the gear. The wheel well doors are hinged to the fuselage and operate hydraulically. The joint where the upper and lower side braces articulate contains the downlock and downlock cylinder.

CYLINDER ACTUATES OVERCENTER SPRING TO CLOSE DOORS



The door cylinder and a spring cartridge operate the gear valve. Points *A*, *B*, and *C* are fixed pivot points. The door cylinder is attached to a crank that pivots about *B*. The doors are shown fully opened (cylinder retracted), and valve actuated. As the cylinder extends, to close the doors, the roller on the door crank pushes the lower finger of the valve actuating lever until the spring cartridge goes past center with respect to *A* and *C*. From this overcenter position, the spring cartridge drives the actuating lever until the spring cartridge bottoms out. The gear valve plunger is fully extended before the valve actuating lever goes overcenter. When the valve plunger is extended, the valve is in normal door closed position and is held in this position by an internal spring.

When the cylinder retracts to open the roller door, the roller on the door crank picks up the upper finger on the valve actuating lever, driving it up and compressing the spring cartridge which goes back overcenter. After the spring has gone overcenter, the roller on the valve actuating lever depresses the valve plunger, actuating the valve to raise or lower the landing gear.

door operation and the door cylinders are not pressurized during the gear operation.

• **If The Hydraulic System Fails**—The 880 has an emergency method of extending its landing gear if the hydraulic system fails. The emergency spool on the main landing gear selector valve in its actuated position vents the entire gear circuit. The emergency door valve (not shown) is operated simultaneously, supplying stored high pressure air through shuttle valves to the door cylinders. If pressurized air is not available, the door uplocks are manually released, then the gear uplocks are also manually released, permitting the gear to fall freely to the down and locked position. The doors are not closed after an emergency gear drop.

The emergency position of the selector valve prevents a hydraulic lock within the gear circuit, so that free fall of the landing gear will be independent of any selector spool position. The two check valves prevent a hydraulic lock in the gear cylinder. If the doors do not open fully, the gear valve will remain in the normal position. Check valve *A* allows fluid to escape from the gear cylinder as it extends. Check valve *B* prevents cavitation within the gear cylinder if the gear valve spool sticks during its stroke.

• **Solving Development Problems**—During initial flight testing, landing gear operation on the Convair 880 was not without its share of problems. The major difficulty was that the gear did not lock up consistently. Also the locked up landing gear was occasionally released. These problems were partly hydraulic and partly mechanical.

• **Surge Unlocked Landing Gear**—When the gear came up and locked, the structure acted as a spring and the gear cylinder acted as an accumulator. In the original configuration, when the gear valve returned to normal position, it released the load on the structure. The gear cylinder would extend slightly, sending a

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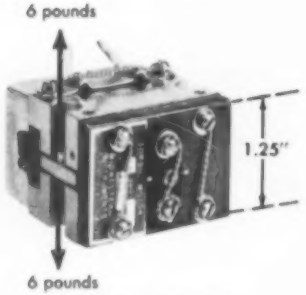

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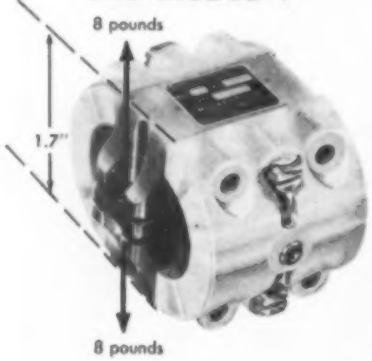

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LANDING GEAR

pressure surge from port C_2 to C_1, retracting the uplock cylinder, and releasing the uplock. The revised drawing shows the same portion of the system after the problem had been isolated and solved. Port C_2 is blocked, not vented, when the valve is in normal position.

• Lock-Up Not Consistent—When the gear came up, on entering the uplock, the door valve was actuated prior to the gear being completely up and locked. As soon as the door started to close, pressure was removed from the gear cylinder, allowing the gear to fall out of the uplock.

Both actions were not consistent. Surge-unlocking depended on the pressure in the gear cylinder at the end of the retraction cycle. Initially, if the pressure was less than 1500 psi as the gear came up, the resulting pressure surge was not enough to release the gear. Non-lock-up was velocity sensitive. The gear would lock up if the inertia of the retracting landing gear was enough to actuate the uplock after pressure had been cut off to the landing gear cylinder. To correct this, the uplock was redesigned so the door valve was not actuated until the uplock was closed completely. In addition, pressure from the door close line was ported to the close end of the uplock cylinder to insure complete engagement of the uplock.

With the landing gear problems resolved, the flight test program has proven the design of this system. The cycle is reversible any time during retraction or extension. The free fall of the gear has occurred at air speeds below original design requirements.

Much of the work on the test stand has been to artificially induce failures into mechanical and hydraulic components. These tests have proved very gratifying. None of these failures have prevented the gear from falling freely to the down and locked position.

Testing on the landing gear test stand and flight testing leave no doubt of the reliability and safety of the Convair 880 landing gear design. ▼▼▼

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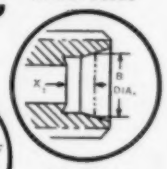

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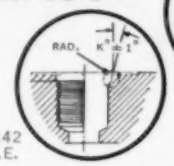

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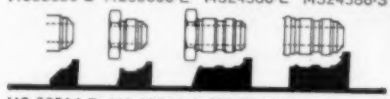

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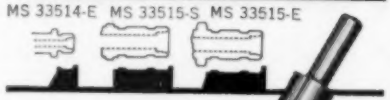

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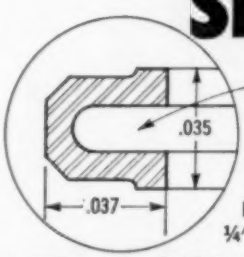

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Britain's new developments in servo systems

• By **G. T. EYNON,** *Chief Experimental Officer, Royal Aircraft Establishment, Farnborough, England*

RECENT developments at the Royal Aircraft Establishment greatly extend the range of single-stage, electrohydraulic servovalves. Design studies show that stiction can be reduced to reasonable levels without using dither. Also, valve reaction forces and high peak pressures can be reduced with improved design. The possible replacement of hydraulic servovalves by pneumatic or hot gas servovalves is considered.

Ruggedness, reliability, and satisfactory performance have been achieved at relatively low cost with the single stage servovalve shown in Figure 1. Experience with the valve on a rocket test vehicle proved this. To extend the range of this 1000-psi, ½-hp servovalve, design studies were made to improve its performance.

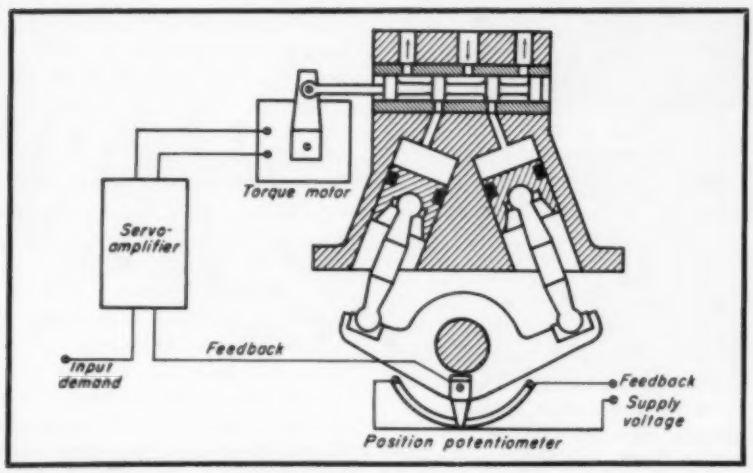

FIG. 1. ELECTROHYDRAULIC SERVO SYSTEM with single-stage hydraulic amplification. This 1000-psi, ½-hp servovalve proved that ruggedness, reliability, and satisfactory performance could be achieved at low cost.

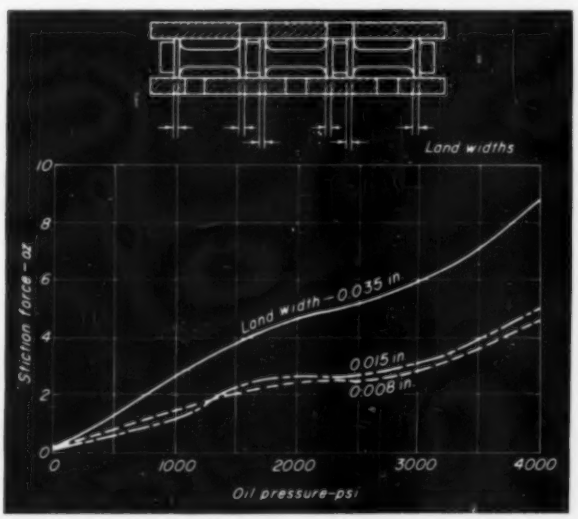

FIG. 2. STICTION IS CUT IN HALF when spool land width is reduced from 0.035 in. to 0.015 in. There is very little improvement by a further reduction to 0.008 in.

• **Reducing Servovalve Stiction**—Valve stiction is caused by dirty hydraulic fluid, components out of round and not parallel, or excessive clearance between the spool and liner. The latter two, cause unbalanced pressure forces around the spool's circumference. Dither is frequently used to reduce these break-out forces. Also, stiction may be reduced almost completely by tapering the spool lands a few 10,000ths of an inch, so that spool clearance is progressively reduced in the direction of leakage flow. Such tapered spool lands are not used because of manufacturing difficulties. Also, the tapers are likely to act as filters and silt up with dirt and cause spool siezure.

The alternative is to reduce the spool area in contact with the liner. That is, the land width is reduced to give the lowest stiction consistent with low valve leakage. Figure 2 shows the variation of stiction with system pressure for various land widths. Reduction in land width from 0.035 in. to 0.015 in. cut stiction in half. A further reduction to 0.008 in. made very little difference, so the manufacturing tolerance for land width was set at 0.015 in. to 0.010 in. For these tests each measurement was taken after the spool was allowed to settle in its center position for one minute. Tests with longer spool settling times—to 6.0 min.—showed no significant increase in stiction force. The spool was 0.1562 in. in diameter. Leakage of hydraulic fluid at 20 C was about 0.122 cu. in./min.

After considering the problems

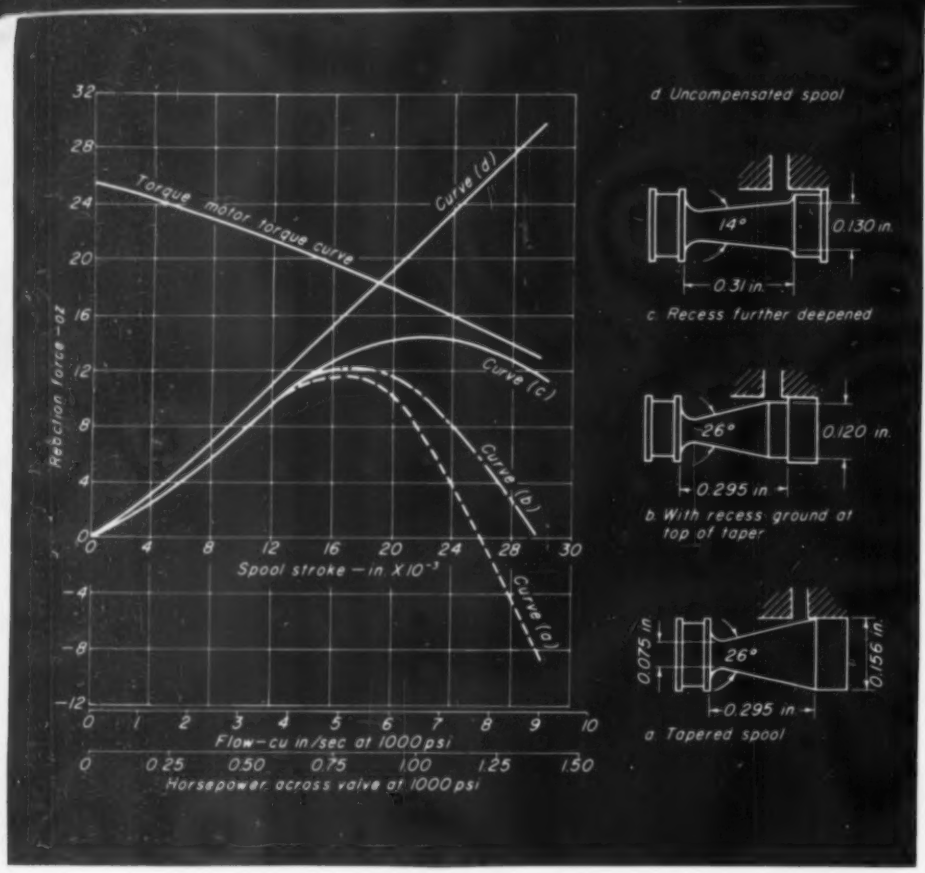

FIG. 3. REACTION FORCE CURVES are for the three tapered spool stems, which are a means of balancing the flow reaction forces on the spool. The reaction forces are balanced or compensated as the valve opens. Balanced forces on the spool allow the single-stage servovalve to be used on higher power applications. Force curve *d* is for an uncompensated spool.

involved in the design and manufacture of servovalves, it was decided to adopt a nominal working stroke of 0.030 in. as a compromise between:

- A low polar moment of inertia of the spool about the torque motor's spindle.
- A stroke long enough to insure that lack of sharpness of control port and spool land edges, and the variations of spool lap resulting from normal production processes, should not affect the linearity of the valve.
- A stroke length convenient for easily reducing valve reaction forces.

Manufacturing difficulties indicated square ports should not be used.

• How To Balance Flow Forces—Lee and Blackburn in their classic papers discussing reaction forces on valve spools, showed that fluid flow around the spool causes reaction forces on the spool. These forces are high enough to limit single-stage servovalves to low power applications. Lee and Blackburn showed that reaction forces can be removed by machining tapers on the spool stem and machining recesses in the liner. Thus the force resulting from flow from pressure to control ports balances out the force resulting from flow to exhaust ports. At least 97% of flow reaction forces can be removed in this way by careful design. For example, with a compensated spool, a 4-watt electrical input to the torque motor and a system pressure of 3000 to 4000 psi, will control 30 hp in a single-stage hydraulic servovalve, and proportionally less at lower pressures.

In many applications, however, it is not necessary to remove the reaction forces completely, but merely to reduce them to a convenient level. They may be reduced by machining a taper on the spool stem, as shown in Figure 3. This produces a reaction force partly positive and partly negative, as shown in curve *a* of Figure 3. This is very undesirable, and may be improved by grinding a recess on top of the taper, as in Figure 3*b*. This results in curve *b*. By making the recess deeper, the force curve is brought to a more satisfactory shape, curve *c*, the reaction level finally selected. In this valve, the reaction force at maximum rated flow of 9.0 cu. in./sec. is reduced to about 40% of its uncompensated value. The force reaction curve for the uncompensated spool is shown in curve *d*. The torque-motor torque curve and curve *c* indicate that the motor and spool torque characteristics match.

• Bleed Orifice Cuts Peak Pressures—In servo systems where inertia is the principal load, high peak pressures are built up in the actuator cylinder when the servovalve closes after meeting a large input demand. Pressures of 14,000 psi on a system pressure of 3000 psi have been measured. Apart from mechanical damage, oil compressibility and actuator distortion at these pressures cause serious servo instability, and severely limit overall servo gain.

By fitting a hypodermic bleed pipe or similar long leakage path across the actuators, high peak pressures are considerably reduced. Over-all servo gain may then be increased. Such a bleed orifice tends to reduce the positional accuracy of the servo, but this is more than offset by improved positional accuracy obtained from increased servo gain. Such a bleed orifice allows actuator power to be greatly reduced and eliminates the need for auxiliary shaping networks to deal with instability.

• Hydraulic vs Pneumatic Servo Systems—In many missiles, stored gas or generated hot gas is the prime source of energy. Though hydraulic systems show a lower system weight for servo systems of 10 hp or more, a considerable saving in system weight, however, is achieved by using the

Continued on page 107

Circle 31 →

your map in a **UNIVERSE** of AIRCRAFT PUMPS

This new engineering bulletin leads you right to the hydraulic pump designs you may be looking for. Here, passing on parade, are high performance gear pumps made to the measure of the next generation in aircraft, missiles, spacecraft, and support equipment.

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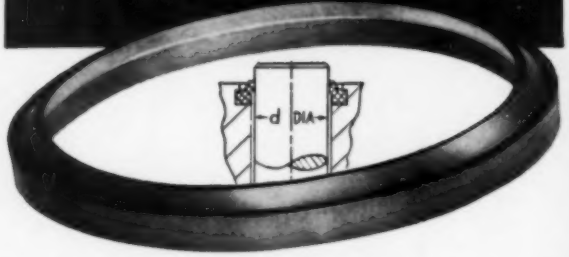

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gas energy to drive the actuators direct at powers below this level. Pneumatic servo systems of less than 1 hp and low pressures (100-500 psi) have been used in the past. As a result, the actuators were bigger and heavier than for comparable hydraulic systems. However, hydraulic actuators require accumulators, reservoirs, pumps, and other equipment. For systems of less than 10 hp, these are the major part of the system size and weight.

On the other hand, because gas is compressible, and to assist in obtaining adequate stability, it is necessary to provide gas actuators with much greater stall torque for a given load. Tests at the Royal Aircraft Establishment have shown that for a given load, a gas actuator must provide at least four times more torque to obtain similar stability. This is achieved by additional stabilizing networks.

Using high temperature gas to drive actuators directly, theoretically offers considerable savings in system size and weight, though the high temperatures present appreciable mechanical problems. To achieve adequate stability it is desirable to:

- Maintain gas pressure in the actuators at least ⅔ of supply pressure.
- Use acceleration and load velocity as additional feedback terms.
- Limit the position-error feedback term to avoid swamping the acceleration and velocity terms during large demand. This leaves servo damping independent of amplitude.

It is also desirable to use a negative pressure lap and a slightly positive exhaust lap on the servovalve to maintain a high standing pressure in the actuators. The velocity terms is particularly useful to get a constant speed of response during the early stages of flight, when the gas loses heat while raising the system to operating temperature. Leakage is considerably greater in a hot gas servo because there must be greater clearance for differential thermal expansion of components.

These gas servo techniques may be suitable in many industries for plant or process control where high pressure steam or other gas is readily available, and where it is difficult or undesirable to use hydraulics or high-power electrical equipment. For up to 5 hp, at least, pneumatic servo systems may well be used in place of hydraulic servos.

This article was prepared from information presented by Mr. Eynon to the Institution of Mechanical Engineers' Symposium On Automatic Control.

DESIGNING ROCKET SERVO SYSTEMS

A rocket test vehicle's servo system must be small, light, reliable, and linear in performance. Its short life requires that it be low in cost. Hydraulic servos are normally used for the vehicle for all except the lowest powers (½ to ¾ hp). Here pneumatic servos have generally been selected. Lowest system weight for a given horsepower is obtained at a pressure range of 3500 to 4000 psi.

Single shot systems are smaller, lighter, and cheaper than recirculating systems for loads of about ⅓ hp with a duration of less than one minute. They use a slow-burning cordite charge to pressurize an accumulator to about 1500 psi. In other cases compressed air or nitrogen at 6000 psi are used to pressurize an accumulator to give a system pressures to 4000 psi. Single shot systems should have very low leakage, so spool underlap and dither cannot be used.

Since the operating temperature range of rocket test vehicles is 0 to 70 C, use of normal aircraft hydraulic fluid (D.T.D. 585) is not essential. Instead, OM-33 or its commercial equivalent is used. It is cheaper and has greater viscosity and lubricity. This reduces servo leakage and stiction and increases pump and seal life. It allows cheaper, lighter pumps to be used.

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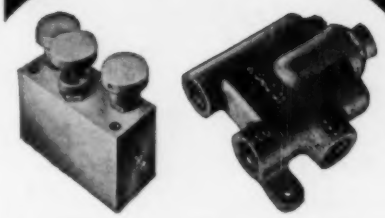

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AEROSPACE COMPONENT DATA

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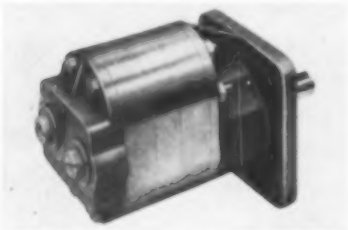

plete system checkout without engine operation.

Specifications: Delivers MIL-F-7024 A, Type II fluid at 3½ gpm and 750 psi. Minimum operational life 1000 hr.—*Eastern Industries, Inc., Hamden, Conn.*

Circle **500** on Reader Service Card

Pressure Vessels To 5000 psi

Booklet contains full-page nomograph for approximating weights of spherical vessels of titanium and steel. Another graph gives curves of strength of pressure vessel materials for various temperatures. Describes making and testing of titanium, stainless steel, and alloy steel vessels for missiles. Pressures from 50 psi to 5000 psi, and temperatures from cryogenic to 280 F.—Bulletin No. 141.—*Airtite Products, Inc., Los Angeles.*

Circle **501** on Reader Service Card

Hydraulic Pump Control Systems

Bulletin describes five special control systems for aircraft and missile, variable displacement hydraulic pumps: electrically depressurized, constant horsepower, load sensitive, dual range, and servo. Each of these systems can be integrated into pumps using either the flat cut-off or the differential cut-off type of control. The pump may be either pressure-compensated, fixed angle type or yoke type. Advantages of each type of control are discussed. Typical regulation curves for each type and specifications on both fixed angle and yoke type pumps are given, including typical pump envelope dimensions. Bulletin A-5259.—*Vickers Incorporated, Div. Sperry Rand Corp., Aero Hydraulics Division, Detroit.*

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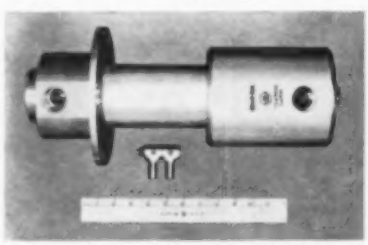
Giant Co-axial Swivel Joint

Features: Hydraulic, three line, co-axial swivel for missile crane turntable permits 180° rotation left and right from a fixed point. The lines are independent of each other and need not be pressurized at the same time. Standard size swivel is shown beside the giant swivel.

Specifications: Two lines are for 1-in. tubing with AND 10050-16 boss connections. One handles hydraulic fluid at 3000 psi and 20



gpm, and the second is a return line for a flow of 20 gpm at 150 psi. The third is a pilot line for ¾-in. tubing for a flow of 3 gpm at 3000 psi. Torque to rotate without pressure is 213 lb-in. Break-out torque with all lines pressurized is calculated at 2000 lb-in.—*The Weatherhead Co., Special Products Div., Cleveland.*

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Pressure Drop Indicator For Filters

Features: Differential pressure indicator for hydraulic filters in high speed servo systems and test stands. Indicator's pointer moved

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Continued on page 110

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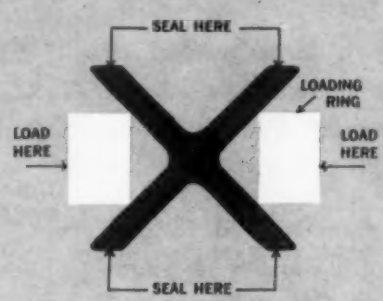

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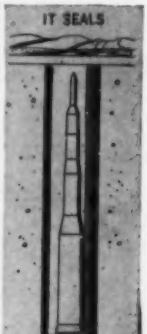

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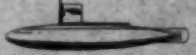

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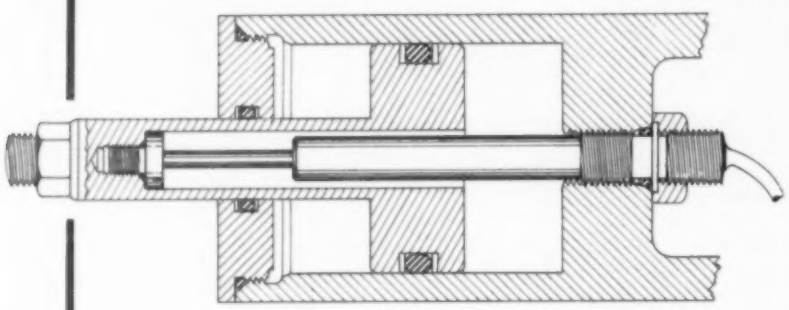

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Length	4⅞"	Scale Factor	12 V/in ± 1%
Diameter	7/16"	Linearity	± ½%
Total Stroke	2.06"	Temp. Range	—65° to +300°F
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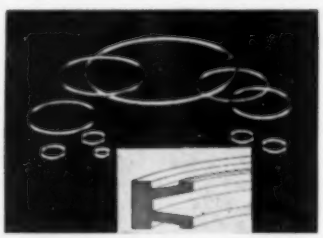
AEROSPACE COMPONENT DATA

sures to 20,000 psi. Manufactured from Inconel X age hardened, A-286 age hardened, 17-4PH to H1150 hardening, 7056-T6 aluminum, 18-8 CRES heat treated and



tantalum annealed. Most of these are available with platings of silver, gold, indium, Teflon, Kel-F, copper, etc.

Designation: HS seal.—*Haskel Seals Div., Haskel Engineering & Supply Co., Glendale, Calif.*

Circle **505** on Reader Service Card

Hermetically Sealed Solenoid

Bulletin describes hermetically sealed solenoid with a life rating of 1000 hr at 1000 F, and will withstand up to 1600 F. Plunger travel is 0.020". Unit weighs 0.28 lb, and is available with rigid or flexible conduit. Bulletin F-10316. —*Barber-Colman Co., Aircraft and Missile Products Div., Rockford, Ill.*

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Custom Asbestos Parts for Severe Service

Packings, gaskets, textiles, and friction materials of special interest to aerospace industries are described in a new catalog offered by Johns-Manville, New York. It emphasizes custom-made asbestos parts for severe service applications where flame, erosion, temperature, chemical action, or high pressures create critical conditions. Included is Thermomat, a new, non-woven, asbestos felt, molding compound in sheet form, for high temperature, abrasive service. The catalog PK-162A, includes considerable tabular data and illustrations of products and their applications. ▼▼▼

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MAGNETIC SEPARATORS

Airborne hydraulic systems are especially sensitive to ferrous particles which may wear off moving steel parts and cause sticking of valves, pistons and other finely fitted components. Remove these particles—even of microscopic size—with FERROFILTERS. The PX series is made for operating at 3000 to 5000 psi; dry weight, approx. 3 lbs. for 12 gpm.

Write for
BULLETIN HP
and Specification Data

S. G. FRANTZ CO., Inc.

658 Kline Ave. at Brunswick Pike
P.O. Box 1138 Trenton 6, N. J.

Circle 37 on Reader Service Card

AEROSPACE NEWS

from the fluid power field

Parker leases service plant in Huntsville

Parker-Hannifin Corp., Cleveland has leased a plant in Huntsville, Alabama where it will service fluid components for space vehicles. The new facility will be operated as a department of the company's Parker Aircraft Division in Los Angeles. Ned Shiflett, former production manager of Parker-Hannifin's Cleveland Accessories Division, will manage the plant.

Pesco names manufacturing director

William J. Whitehouse has been appointed director of manufacturing of Pesco Products Div., Borg-Warner Corp., Bedford, Ohio. He had been production manager for three years. Whitehouse will head the manufacturing operations for the Pesco product line of aircraft and missile components.

Whitehouse

Billet

Billet elected president of IES

Arthur B. Billet, senior staff engineer of Vickers Incorporated, has been elected president of the Institute of Environmental Sciences. Billet has been a vice president of the national organization for the past five years. The IES is the only technical society devoted to the study and test simulation of environments found in space, marine, and ground operations.

SAE pneumatics and hot gas chairmen appointed

Hydraulics and Pneumatics A-6 Committee Chairman B. R. Teree announced that Dave Grant is the new chairman of the Pneumatics Subcommittee, A-6B. Grant is Chief of Missile Accessory Design, Hughes Aircraft Division, Culver City, Calif. Additional job responsibilities caused Charles H. Cannon, Jr., former Pneumatics Chairman to resign his position. However, he will remain a member of the A-6 Committee.

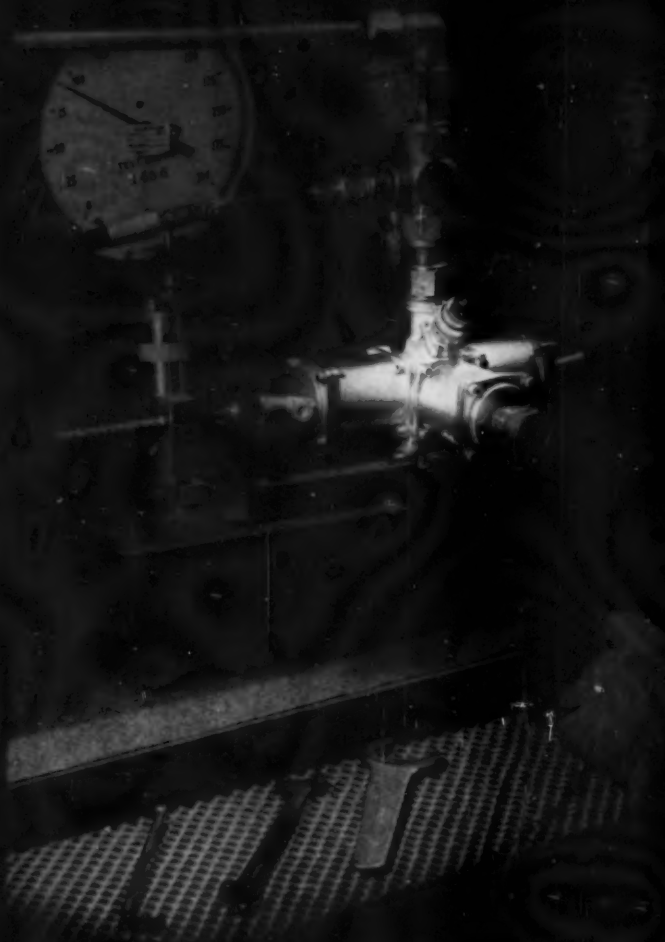
The new Hot Gas Systems Panel Chairman is Howard E. Wright, Senior Hydraulic Design Group Leader, Convair-San Diego. He replaces Eugene T. Raymond, Chief of Mechanical Design Research, APS, for Boeing Aero-Space Division. Raymand has taken on new responsibilities in the Dyna-Soar program.

Sperry awarded Boeing flight system contract

The Boeing 727 Jetliner, first of a new generation of commercial jets, to enter passenger service in 1963, will have an automatic flight control system developed by Sperry Phoenix Co., Div. of Sperry Rand Corp., Phoenix, Arizona. The basic design of the system, called SP-50, has already been proved in flight. The SP-50 system includes: A flight controller through which the pilot inserts commands to the automatic control system. Sensory equipment senses variations in the normal flight axes. Electronic computers and amplifiers receive signals from the flight controller and sensory equipment and compute commands for hydraulic actuators which control roll, pitch, and yaw. ▼▼▼

Circle 120 →

Watch Weston for new developments...



Space satellite
REACTION THRUST VALVE
gets "show window" testing at Weston!

Exotic in both design and application, this reaction thrust valve developed by Weston Hydraulics is used to stabilize and control TV satellites while in orbit. Used in pairs, each valve is actually three valves in one, the pair controlling all three axes of roll, pitch and yaw. A 14 kt gold plating helps regulate temperature and provides resistance to corrosion. ■ Weston's facilities are just as modern as the products they put out. The pneumatics laboratory, shown here, is one of the largest and best-equipped available, with special windows for safe testing to 5,000 psi! ■ Put Weston's experience to work for you. Write or call for information on a hydraulic, pneumatic or gas actuated control system for almost any application!

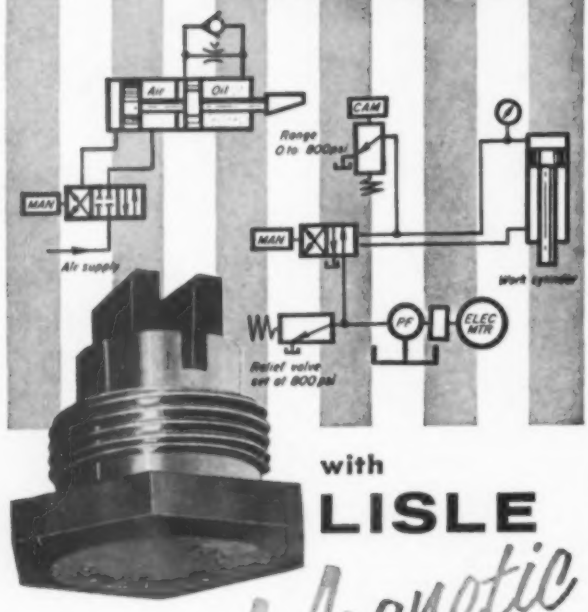
Special windows for high pressure testing have 1" thick bullet-proof glass in this Weston lab.

weston
HYDRAULICS LIMITED
A SUBSIDIARY OF BORG-WARNER CORPORATION

WESTON HYDRAULICS B-W BORG-WARNER

7500 Tyrone Ave., Van Nuys, Calif. • Telephone TRiangle 3-4340

HYDRAULIC SYSTEMS PERFORM BETTER



with

LISLE *Magnetic* PLUGS

Fouled valves and excessive pump wear are frequently caused by abrasive ferrous metal particles that are circulating in the fluid of a hydraulic system.

You can eliminate this problem by installing a Lisle Magnetic Plug in the flow path or sump. The powerful magnet in the Lisle Plug attracts and holds these ferrous particles; assures better performance of the entire hydraulic system.

LISLE CORPORATION
CLARINDA, IOWA

Write for Catalog and Test Samples.

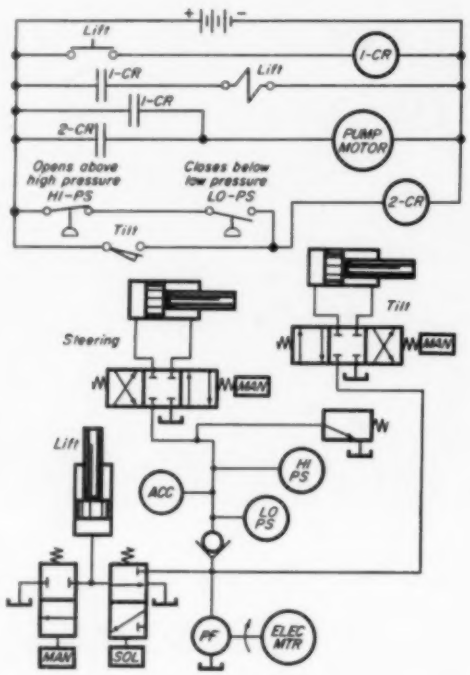
Circle **66** on Reader Service Card

FLUID POWER PATENTS

Efficiency Circuit for Lift Trucks

This system uses an accumulator to store fluid under pressure for steering. Pressure switches start the pump motor when system pressure falls to a set limit, and stop the motor when system pressure reaches its high limit.

• **Accumulator Charged While Extending Lift Cylinder**—When the *LIFT* pushbutton is pressed, energizing 1-CR, the *LIFT* solenoid valve is energized, connecting the pump to the lift cylinder. Energizing

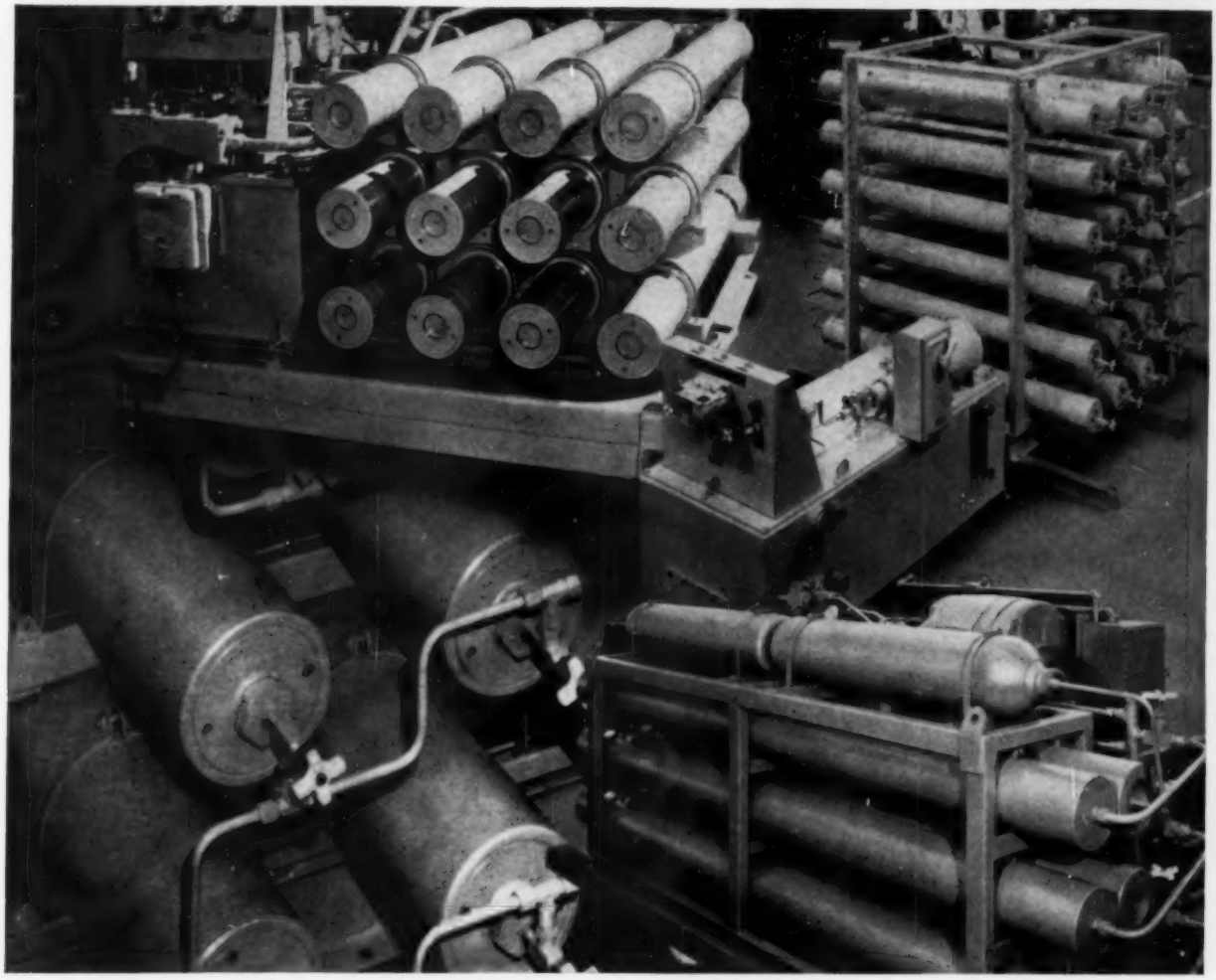


1-CR also starts the pump motor. The pump operates until the pushbutton is released. If the accumulator is not fully charged, the pump motor continues to drive the pump, because it is energized through contacts of 2-CR. Both *HI-PS* and *LO-PS* are closed at low pressure, energizing relay 2-CR. When the accumulator is fully charged, the high pressure switch opens, breaking the circuit to 2-CR. Its contacts open, breaking the circuit to the pump motor.

Operation of the tilt cylinder control valve closes the *TILT* limit switch contacts which start the pump motor, actuating the tilt cylinder and charging the

Continued on page 116

Now... more new accumulators from AMERICAN BOSCH!



AMERICAN BOSCH ACCUMULATORS are tailored to fit the job!

Now—American Bosch offers the most complete line of piston-type accumulators on the market! Sizes range from less than a quarter pint to twenty gallons. Models are available for a variety of pressures in both steel and aluminum—in many diameters, lengths and capacities to handle any job.

American Bosch accumulators are designed and manufactured to meet the most rigid requirements. They combine many features to provide the utmost in performance and reliability.

When you specify accumulators for hydraulic systems—call for AMERICAN BOSCH ACCUMULATORS! Details are included in folder AC 110-02-2. Write for a copy and the name of your nearest distributor.

AMERICAN BOSCH ARMA CORPORATION

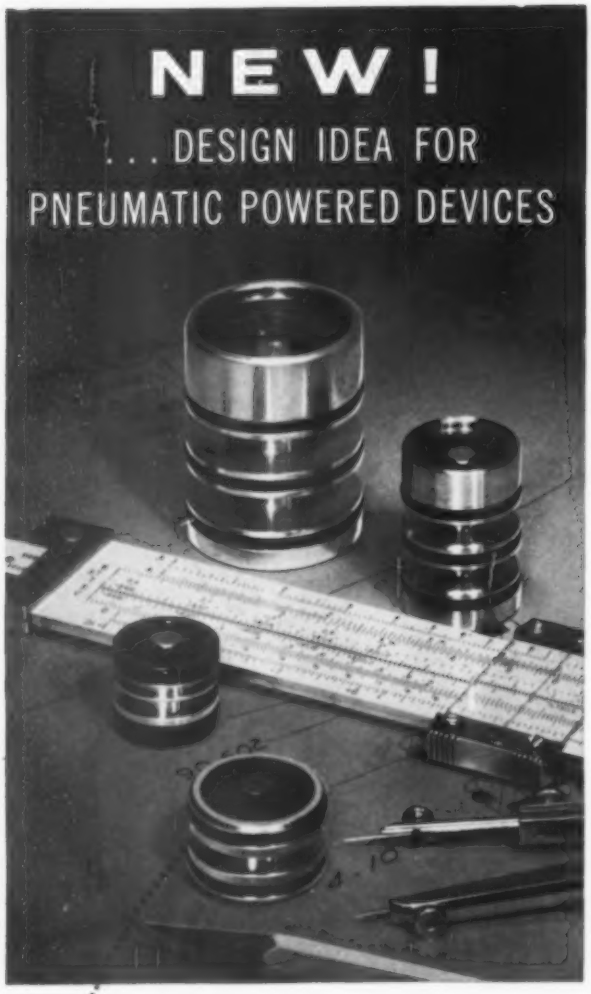
Commercial Sales Division • Springfield, Massachusetts

MOVE AHEAD with AMERICAN BOSCH ARMA

ACCUMULATORS FOR INDUSTRIAL, MARINE AND MOBILE APPLICATIONS

6269

Circle 5 on Reader Service Card

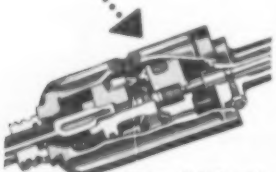


. . . Put Humphrey Cartridge Type Insert Valves INSIDE YOUR PRODUCT

These Humphrey "Quick-Dump" Valves are installed by dropping them into a machined cavity, *inside* the cylinder, manifold, control handle, etc.

They save weight, cut material and component costs, reduce assembly time, speed up production. They eliminate the plumbing, permit installing multiple valves in small space, help simplify, miniaturize and clean up product design.

Choice of 2-way or 3-way, in ⅛" or ¼" sizes, for manual, electric or piloted operation. *Write for bulletin pictured below.*

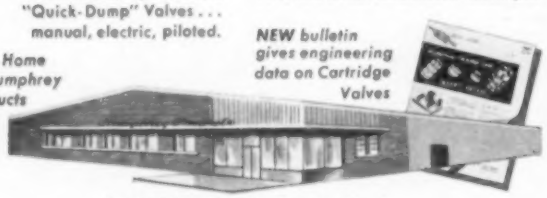


Also — full line of conventionally mounted "Quick-Dump" Valves . . . manual, electric, piloted.

Humphrey PRODUCTS
Div. of General Gas Light Company
P.O. Box 2008, Kalamazoo, Michigan

NEW bulletin gives engineering data on Cartridge Valves

New Home of Humphrey Products



Circle **53** on Reader Service Card

accumulator. In this manner, the accumulator is charged during each operation of the lift and tilt cylinders.

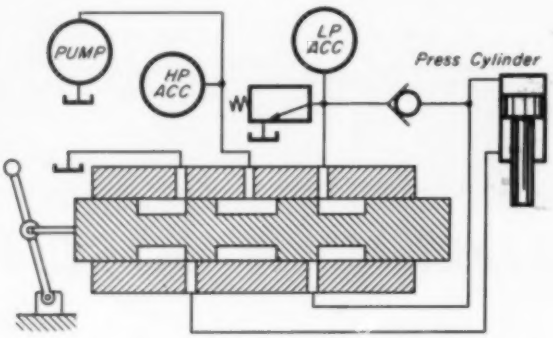
Pressure fluid for power steering is furnished by the accumulator. If accumulator pressure falls, the low pressure switch contacts close starting the pump motor. The pump operates until the accumulator is charged and the high pressure switch opens.

U. S. Patent No. 2,968,927 by George F. Quayle, assigned to The Yale & Towne Mfg. Co., Stamford, Conn.

Accumulators Give 2-Pressure Press Circuit

Generally a press circuit that supplies low pressure fluid for closing and high pressure fluid for squeeze requires a 2 pump power source and considerable valving.

To get the same results with one pump, this circuit retracts the press cylinder with pressure from a high pressure accumulator, and charges a low pressure accumulator with fluid forced from the cylinder's head end. Fluid from the low pressure accumulator extends



the cylinder. A special control valve then shifts from low to high pressure for the squeeze.

• **Relief Valve Limits Accumulator Pressure**— Moving the valve operating handle to the right connects the rod end of the cylinder to tank. Fluid from the low pressure accumulator flows through the check valve and into the head end of the cylinder, which extends at low pressure. To start the squeeze, the control valve is moved farther right, connecting the cylinder's head end with the high pressure accumulator.

The cylinder retracts when the control valve is moved left, connecting the pump and the high pressure accumulator to the cylinder's rod end. While retracting, fluid from the head end of the cylinder flows through the control valve and charges the low pressure accumulator. Excess fluid from the cylinder's head end flows through the relief valve which is set to limit pressure in the low pressure accumulator.

U. S. Patent No. 2,977,763 by Jean Mercier, N. Y.

Circle **32** on Reader Service Card

your guide to the gear pump for your application

Searching for a gear pump with top volumetric efficiency?

• Eastern 1200 series – up to 1.6 gpm – pressures to 800 psi • Eastern 100 series – up to 5 gpm – pressures up to 1500 psi • Eastern 700 series – up to 9.8 gpm – pressures up to 1500 psi. Save hours of searching your way through the gear pump maze – send for catalog 810 now!

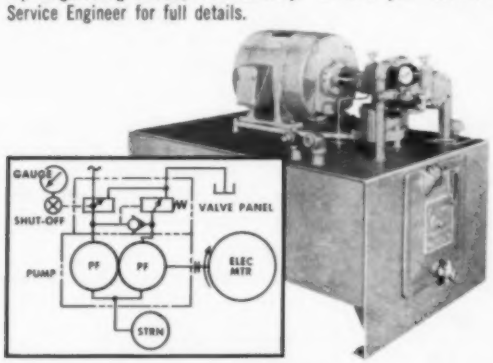
Other Eastern products:

- hydraulic motors
- centrifugal pumps
- positive displacement pumps
- aircraft pumps

EASTERN INDUSTRIES, INC.
Hamden, Connecticut

PICK CARDWELL'S Standard Hydraulic Power Unit Program

Provides a simple means of selecting the right hydraulic components for your specific job. Standard units readily available plus top engineering advice, fast delivery. Contact your Cardwell Service Engineer for full details.

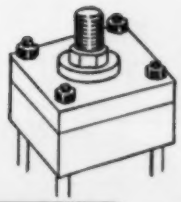


Model: PFB double—100 Series—2000 PSI Max.
Tank Capacity: 30-60 gal.
Pump Deliveries: 1.5, 3, 5, 8, 11 combinations @ 0 PSI, 1200 RPM. Other volumes proportional @ 0 PSI, 1800 RPM.
Motor Horsepower: As required

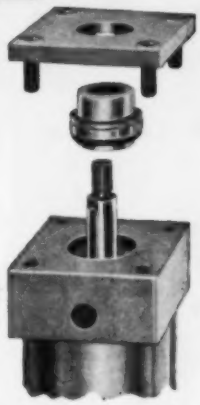
The **CARDWELL MACHINE COMPANY**
RICHMOND, VIRGINIA

Circle **18** on Reader Service Card

Why This?



When This Can Be Yours!



Mo-Bar Air and Hydraulic Cylinders cannot fall apart . . . because of loose tie-rods . . . when you remove the rod bushing and cartridge retainer plate of these cylinders.

Mo-Bar's *exclusive* feature of using four (4) Allen Head cap screws in place of conventional protruding hex nuts . . . permits easy, quick replacement of the entire cylinder Rod Cartridge assembly . . . with cylinder barrel and tie-rods always permanently in place.

This Mo-Bar "first" gives greater design flexibility . . . particularly for cylinder mounting in tight places.

Other Mo-Bar "firsts" include (1) improved Rod Cartridge design where the long bronze rod bushing is *piloted* into cylinder head—not threaded—for maximum piston rod support . . . and (2) oil-heat resistant, self-adjusting Seal Guard wiper rings, with long conical taper, to throw off all harmful matter from piston rods.

The unique Mo-Bar compact design for air and hydraulic cylinders assures superior performance and unfailing dependability with positive, uniform actuation at all times.

There are Mo-Bar Air Cylinders, series 'a'—1½" to 14" bore, to 200 psi . . . Mo-Bar Hydraulic Cylinders, series 'm' (medium pressure)—1½" to 14" bore, 500 to 2000 psi . . . Mo-Bar Hydraulic Cylinders, series 'h' (high pressure)—1½" to 12" bore, 2000 to 3000 psi.

Write for all three bulletins—Nos. 202, 203 and 204—describing Mo-Bar Air and Hydraulic Cylinders for fluid power applications . . . Dept. B

MO-BAR HYDRAULICS CO.
Crystal Lake, Illinois

Circle **75** on Reader Service Card

put Pumcups
in your cylinders

TO HOLD PRESSURE LONGER!

In Darcova Pumcups a sound engineering principle has been combined with precision tolerances and extremely durable compositions to provide exceptional efficiency and life in hydraulic, air, and reciprocating pump cylinders of all kinds.

Unlike ordinary piston packing, precision Pumcups are engineered to minimize friction load while hugging cylinder walls on every pressure stroke. Regardless of eventual wear, efficiency *stays* high! So there's far less down-time and need for replacement.

Pumcups are made in a wide range of sizes, types and texture-engineered compositions, including 100% Nylon, for all kinds of pressure-temperature-fluid conditions. Send for Pumcup Bulletin 5903 and weigh all the facts!

DARLING VALVE & MANUFACTURING CO.
Williamsport 15, Pa.

DARCOVA
THE ORIGINAL COMPOSITION CUP
TRADE MARK
PUMCUPS

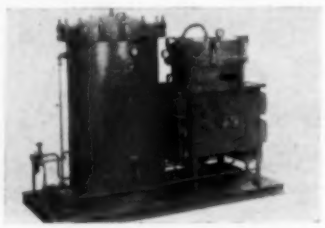
Circle **28** on Reader Service Card

NEW PRODUCTS

Continued from page 52

OIL FILTER, RECLAIMER

For compressors, vacuum pump lubricating and sealing oil. Unit motor pump forces oil through filter at any flow rate. All or part of oil is diverted to reclaimer for



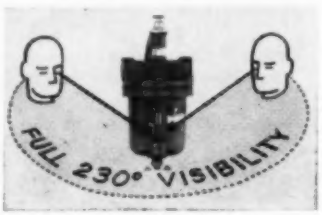
final polishing and volatile contamination removal. Piping allows filter to operate alone, reclaimer alone, or both in series. Various filtering materials handle specific oils.

Designation: Hilco. *The Hilliard Corp., Elmira, N. Y.*

Circle **319** on Reader Service Card

SAFETY BOWL

For compressed air filters and lubricators. Bowl is die cast of zinc alloy, and has a sight level indicating gauge that can be rotated to face any direction. Tempera-



ture, pressure, and corrosive resistant. Indicator is made of pyrex tubing protected by a thin metal strip along its length. Visibility 230 deg.—*Wilkerson Corp., Englewood, Colorado.*

Circle **320** on Reader Service Card

SPECIAL O-RINGS

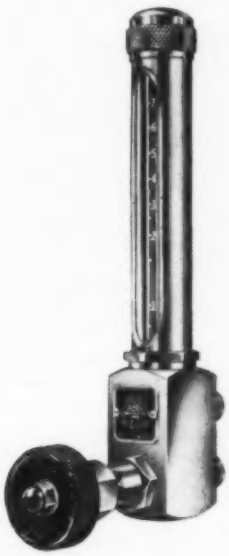
Specifications: Any diameter over 6". Standard cross sections .139 ±.004" and .275" ±.006". Others available. New process eliminates flash. Produced in a variety of elastomers for practically all types of hydraulic media.—*Kalendex Div., Periflex, Inc., Madison Heights, Michigan.*

Circle **321** on Reader Service Card

HOKE Flow Sheet 6

HOKE REPORTS ON FLUID CONTROL

MEASURING, METERING AND DO-IT-YOURSELF



FLOW WATCHING FOR FUN AND PROFIT

(Follow the bouncing ball)

After making flo-gages for longer than we'd like to remember, we've come to realize that there's no one simple answer to the problems of flow measurement. Rather than try to solve everyone's problems at once, we've concentrated our efforts in the low, but delicate, flow ranges.

The variable area principle (the ball float in tapered tube bit) is nothing new, and we haven't done much to advance science here. But what we have done is to build some direct reading flo-gages that provide pretty accurate pictures of the downstream activities of some of your favorite gases. Depending on the gas you're using, we've made units with maximum ranges from 0.7 liters per minute up to 44 cubic feet per hour, and we've even built a needle valve into one unit for fussy flow watchers.

Serious hydrodynamicists (flow watchers, to you) will be happy to hear that they can get Hoke flo-gages in straight, angle and panel mounting models.

For a guide to flow-watching, make your mark in the box on the right.

One good turn deserves another, and it takes twenty to move the stem of the Hoke 280 Series metering valve from the closed to the full open position — a total of 9/16". And in case you lose count (or can't count) we can supply it with a vernier handle that shows turns and fractions of turns for accurate re-set.

What you're moving when you twirl the wheel on this bar stock needle valve is really a needle. It has an 8° included angle and seats in either a .062 or .125 orifice, so you can see it's possible to turn down to a pretty accurate trickle. If an 8° included angle will still not give you the control you want, we've turned stems that read out to a 1° included angle.

Now, here's a real stopper—a Teflon seat. In this modification, the needle is spring-loaded so that it can't gall, or be scored. And it's backed by a Teflon seat for positive shut-off. This seat bottoms on a raised orifice in the valve body and can be used to hold pressures up to 3000 psi. Vacuum's a snap, too.

If these facts leave you still unmoved, we've got a few more gems to dazzle you with. For instance, you can use these valves to temperatures up to 450°F. And you can choose from brass or 316 stainless steel.

And if you're one of those people who must be different, why not build one yourself. It's easy and you can do it by reading our 280 Series Data Sheet. All you need is a screw machine, turret lathe, milling machine and a few other easily acquired gadgets. However, if things don't work out too well, you can still get them from us.

To be really knowledgeable in the field of fine metering, all you have to do is read the facts in the Data Sheet. A check in the 280 box will bring you instant information.

'61 PRODUCT PARADE

You'd be surprised at some of the screwball ways our valves have been used (to decided advantage, of course). Hoke distributors are armed to their maxillary third molars with this method madness and will redesign your systems with new Hoke products at the drop of a postcard. Check the PRODUCT PARADE Box.

Hoke's Performance Guarantee—*Every Valve Leak-Tested!*

HOKE INCORPORATED
87 Piermont Road, Cresskill, N. J.

Send me complete information on the Hoke products checked below:

- ☐ 280 Series Metering Valves
- ☐ Flo-gages
- ☐ '61 Product Parade
- ☐ Complete Catalog GC 960

NAME_____ TITLE_____

COMPANY_____

ADDRESS_____

CITY_____ STATE_____

SEE OUR CATALOG IN SWEETS PRODUCT DESIGN FILE

Circle 51 on Reader Service Card

Absolutely No Leakage at 6000 psi

. . . and that's only one of the reasons why CPV O-SEAL valves and fittings are being designed into both new and existing high pressure systems. "Bubble-tight" shut-off of liquids and gases — even nitrogen and helium — is assured at temperatures from —20°F. to 275°F.

O-SEAL valves and fittings can be quickly installed, repositioned or relocated with hand tight connections that remain leakproof and vibration-proof well above their nominal 6000 psi rating. Unions, elbows, tees and fittings, in addition to shut-off, relief and check valves, provide unequalled design and installation flexibility.

The BIG difference is the way O-SEAL design uses pressure to eliminate leakage at the stem, seat and end connections. Exceptionally low torque insures hand operation of any shut-off valve from 1/8-in. to 2 in. regardless of pressure.

Full details and specifications are given in 36-page Catalog 60. Write today for your copy.

CPV

COMBINATION PUMP VALVE CO. / 846 Preston Street, Philadelphia 4, Pa.

Circle **25** on Reader Service Card

NEW PRODUCTS

HYDRAULIC PUMP UNITS

Self-contained units for industrial machinery applications such as lift trucks, small clamping mechanisms, and gate valve operations. Base of unit forms oil reservoir. Motor, pump, filler and breather, and pressure and return connection mount on an aluminum die casting base plate that forms reservoir cover. Four bolts hold assembly.

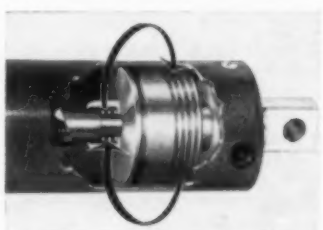
Specifications: Pressures to 2500 psi. Flows from .6 to 4.2 gpm.

Designation: Junior.—*Racine Hydraulics & Machinery, Inc., Racine, Wisc.*

Circle **322** on Reader Service Card

STROKE ADJUSTING CYLINDERS

If fractional inch stroke length is desired, nearest larger integer length can be ordered then reduced to requirements by removing front spacing washers and adding same amount of rear washers.



This reduces stroke length without disturbing mounting dimensions.

Specifications: Uses series of 1/16" thick spacing washers to position piston on piston rod. In stock stroke lengths of 1" increments.

Designation: Adjust-O-Stroke.—*Modernair Corp., San Leandro, Calif.*

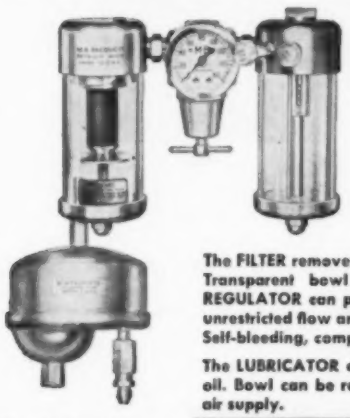
Circle **323** on Reader Service Card

Circle **68** on Reader Service Card

GREATER PROTECTION to your AIR LINE!

M-B

WHIRL-A-WAY FILTER, REGULATOR AND LUBRICATOR ASSEMBLY AND AUTOMATIC AIR TRAP (MODEL W-4)



SUCCESSFULLY USED FOR PROTECTION OF AIR VALVES CYLINDERS CONTROLS PNEUMATIC TOOLS, ETC.

The FILTER removes solids .00039 and larger. Transparent bowl provides visibility. The REGULATOR can pass large volume with an unrestricted flow and minimum pressure drop. Self-bleeding, compact.

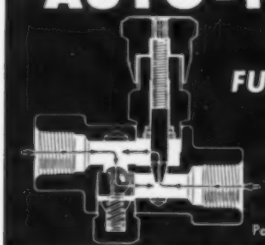
The LUBRICATOR delivers desired volume of oil. Bowl can be refilled without shutting off air supply.

The Air Trap is automatic and eliminates manual draining.

M-B PRODUCTS
46 VICTOR AVE., Div. 12
DETROIT 3, MICHIGAN

AUTO-PONENT®

HYDRAULIC FULL FLOW VALVES



Flow Control, Needle, Check, for HYDRAULIC Power

Model KF Flow Control Valve with Dial and Knob adjustment for direct reading and duplicating reference. Now available in Aluminum for 3000 psi.

Pat. #2,841, 174

A complete line: 1/8", 1/4", 3/8", 1/2", and 3/4" female Dryseal Pipe Sizes in all models and types. Equivalent Aeronautical Tube Sizes on special order.

MINIMUM PRESSURE DROP AND POWER LOSS . . . Oversize ports and passages give maximum flow at minimum pressure drop, insure greater accuracy and response in hydraulic or large volume air cylinder control.

EASY FLOW ADJUSTMENTS under full pressure. Seal located at port to eliminate air or dirt traps. Gland structure equally effective on pressure or vacuum.

SENSITIVE, CHATTERLESS BALL CHECK . . . Patented design insures rapid ball movement to open or close at low differentials.

FORGED BODIES permit higher pressures with wide safety margins. Aluminum—3000 psi; Steel and Stainless Steel—5,000 psi. Pressure ratings based on better than 5 to 1 safety factor. All internal parts are Stainless. Write for illustrated catalog.

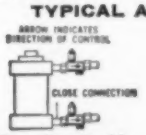
Model F Standard Flow Control Valve or Model N Needle Valve

Model KF Knob and Dial Flow Control Valve or Model KN Needle Valve.

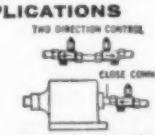
Model PF Knob and Dial Flow Control Valve or Model PN Needle Valve for panel mounting.

Model C Check Valve for In-Line Mounting.

TYPICAL APPLICATIONS



Controlling Double Acting Cylinder



Controlling Single Acting Cylinder

AUTOMATION AUTO-PONENTS INC.
2919 GRANT STREET
BELLWOOD (Chicago Suburb) ILLINOIS

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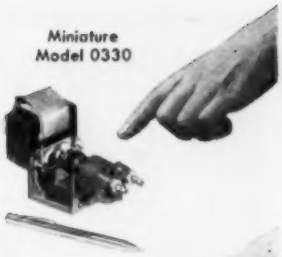
Miniature Model 0330

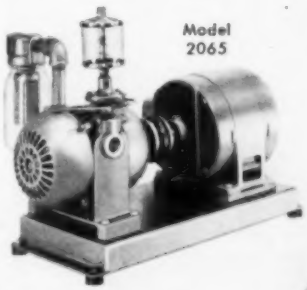


THE "BIG IDEA"

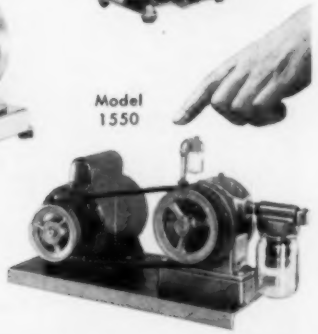
OFTEN, PROBLEMS OF PRODUCT FUNCTION CAN BE SOLVED WITH AIR PRESSURE OR VACUUM. "AIR MAY BE YOUR ANSWER!"

Model 0211

Model 2065



Model 1550



For the Type, Size, Drive you need— specify

GAST VACUUM PUMPS and AIR COMPRESSORS

On your current design project, consider the benefits Air offers. Applied as pressure or vacuum, it solves many knotty functional problems better than other methods.

It's versatile...easily controllable...and economical. With a small Gast Air Pump, you can provide great force and power. Use air to hold, lift or feed materials . . . to fill or evacuate . . . convey solids or liquids . . . move or reciprocate parts . . . to pressurize, agitate, atomize, oxygenate . . . and for controlling, sampling, testing.

The Gast Line of Air Pumps offers you a wide range for selection. Simple, rotary-vane design is dependable . . . and maintains high efficiency. Air delivery is "pulseless" and quiet. So consider using air on your product—and check with Gast for engineering suggestions.

LUBRICATED AIR PUMPS	OIL-LESS AIR PUMPS
SERVICE. Light-duty, Heavy-duty	SERVICE.....Light-duty
CAPACITIES....0.6 to 50 c.f.m.	CAPACITIES...0.35 to 24 c.f.m.
VACUUM.....To 28" Hg.	VACUUM.....To 25" Hg.
PRESSURE.....To 30 p.s.i.g.	PRESSURE.....To 15 p.s.i.g.
MOTORS.....1/12 to 5 h.p.	MOTORS....1/40 to 1½ h.p.
DRIVES.....Integral-motor, Direct coupled, V-belt	DRIVES.....Integral-motor, Direct coupled, V-belt

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Air Motors • Vacuum Pumps • Compressors

GAST MANUFACTURING CORP.
P.O. BOX 117-D, BENTON HARBOR, MICHIGAN

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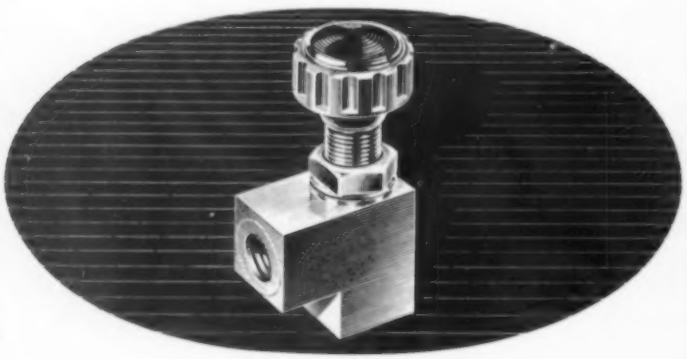
PRECISION MADE FOR PERFORMANCE!

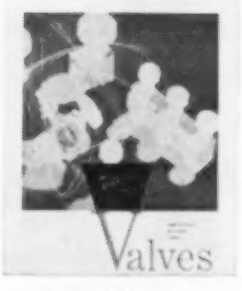
ROBBINS VALVES DESIGNED TO SAVE YOU MONEY!

Why let replacement costs and downtime caused by inferior valves ruin your scheduling and waste your money?
ROBBINS VALVES are specifically designed to prevent and eliminate such waste. Design capabilities, test programs, manufacturing procedures, quality control (and even packaging) at Robbins are all directed toward one objective... to produce and offer valves of highest quality that will give you the greatest possible economy and reliability over many years of service.



A FEW OF THE FEATURES OF THAT WILL PROTECT YOUR BUDGET ROBBINS VALVES

* Over 4 to 1 burst factor
* Quality valves that can be completely serviced in less than 1 minute from the front of the mounting panel without removal from the line
* As many as 5000 cycles at full pressure rating before requiring service
* Barrel, spindle, spindle seals, barrel seals and seat in one complete barrel assembly, one unit
* Approved military specification quality control... for both military and civilian valves... meeting or exceeding MIL-Q-5923 and MIL-Q-9858
* All valves LOX cleaned... assembled and packaged to standards recommended by Aero Space Industries Ass'n.
* Shut-off's as low as 1 in-lb. at 1000 PSI... bubble tight
* Minute metering characteristics
* Replaceable soft seat
* Backed by warranty



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HI-VACUUM TO 12,000 PSI! • OXYGEN • HYDRAULIC • PNEUMATIC • ANGLE GLOBE • THREE-PORT • MANIFOLD

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NEW PRODUCTS

CARTRIDGE-TYPE RELIEF VALVE

This high capacity, low-cost, differential piston relief valve cartridge is less than 4" long and is

made from 1" hexagonal steel bar stock. It handles flow capacities up to 40 gpm with low pressure rise. Cartridge can be inserted into a simply machined cavity in a multi-valve manifold or body—No cast or machined annuli are required.
Specifications: Valve is available in three adjustment ranges: 200 to 1000 psi, 500 to 2000 psi, and 1000 to 4000 psi.—*Fluid Controls Inc., Mentor, Ohio.*

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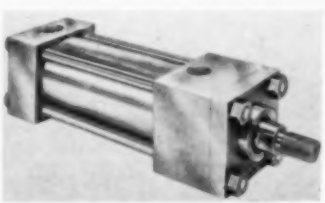
AIR CYLINDER

Series K air cylinder, rated 200 psi, has a cold drawn brass cylinder barrel, and a hard chrome plated, high tensile steel piston rod with a minimum yield strength of 90,000



to 100,000 psi. Rolled steel heads are machined for perfect alignment of piston rod.
Specifications: Available for bore sizes of 1½" to 14".—*Ortman-Miller Machine Co., Hammond, Ind.*

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SELF-CLEANING LINT FILTER

Removes lint, chaff, leather cuttings, and other large particles from air. Brushes clean filter media.
Specifications: Sizes from 7000 to 150,000 cfm. Air flows from 250 to 1900 fpm.
Designation: Lint-A-Maze.—*Air-Maze Div., Cleveland.*

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PRODUCT BRIEFS

MOBILE SECTIONAL VALVE . . . As many as 8 sections can be used. Banks of 3-way, 4-way, free flow, or 4-position, using SAE or NPTF threads. Maximum pressure 2500 psi; 35 gpm capacity.—*Gresen Mfg. Co., Minneapolis*

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SOLENOID VALVES . . . The X10 Series high pressure, explosion proof, solenoid valves are for hydraulic systems to 2000 psi—*Skinner Valve Div., Skinner Precision Ind. Inc., New Britain, Conn.*

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ALL-METAL SWIVEL JOINT . . . Operating range of −425 to +1500 F. Pressures to 1500 psi and higher; available in ½" tube size.—*Sealol Inc., Providence, R. I.*

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OIL SEAL . . . P/S Klozure shaft oil seal has filled-Teflon sealing element, seals at speeds to 3000 fpm. —*Garlock Inc., Palmyra, N. Y.*

Circle **330** on Reader Service Card

2000-PSI CYLINDERS . . . 1½" through 8" bores; 20 mountings, tie rod construction. Wrench removes rod cartridge. Multilip rod packing.—*Sheffer Corp., Cincinnati*

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COMPRESSED AIR DRYERS . . . Three sizes added to line bring total of 40 capacities from 7.5 to 11,080 cfm at 100 psi. Extracts water vapors, acid fumes, foreign particles.—*Van Products Co., Erie, Pa.*

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AIR-OIL TANDEM CYLINDERS . . . Tom Thumb cylinders in ¾", 1", and 1¾" bore, 8 mountings; maximum pressure of 200 psi.—*Pneumatic-Hydraulic Development Co., Tom Thumb Div., Fort Wayne, Ind.*

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RECIPROCATING AIR COMPRESSORS . . . Single and 2-stage units 50 psi and 125 psi. 7½ to 150 hp. Suction valve type unloaders.—*Davey Compressor Co., Kent, Ohio*

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HYDRAULIC CYLINDERS . . . 1½" to 6" diameter bores, pressures to 1500 psi. Steel barrel for rigidity; close fitting iron piston for long bearing.—*Milwaukee Cylinder Co., Cudahy, Wis.*

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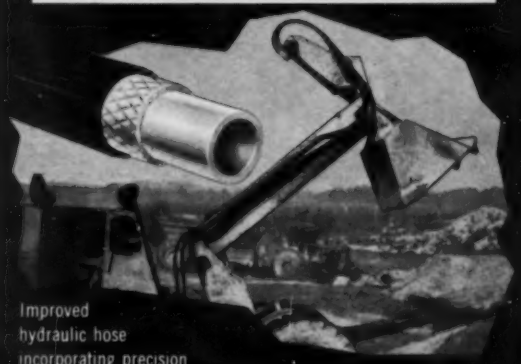
SYNFLEX
Pressure Hose



Improved hydraulic hose incorporating precision drawn nylon inner tube, nonmetallic reinforcing braid, abrasion-resistant extruded cover. Electrical non-conductor.

■ **Synflex Pressure Hose** is a new concept in high pressure hose for multi-purpose applications. Combines strength with light weight . . . no metal to fatigue . . . low cost. Use with water, fuels, oils, gases, solvents, refrigerants, conventional and non-flammable hydraulic fluids. Available with reusable couplings in a range of sizes from 3/16 thru ¾ ID and larger.

Specify SYNFLEX
Plastic Tubing

V • 1 CLEAR VINYL
Glass-clear . . . non-toxic . . . odorless and tasteless . . . flexible yet tough . . . easy to clean or steam sterilize . . . never kinks. Sizes: ⅛ thru ⅜ ID in ⅛ increments, all with ⅛ wall.

P • 1 POLYETHYLENE
Precision extruded to closest tolerances . . . high molecular weight . . . virgin resin free from impurities or imperfections. Natural and 7 fade resistant colors. Sizes: ¼ OD with .040 wall, ⅜ and ½ OD with .062 wall.

N • 3 NYLON HYDRAULIC-PNEUMATIC
Ideal pressure tubing made from precision extruded nylon . . . strong and flexible . . . superior fatigue, corrosion and abrasion resistance . . . installs fast. Sizes: ⅛ thru ⅜ in various wall thicknesses.

A-1000A

SYNFLEX
Products Div.
Samuel Moore & Co.
Mantua, Ohio

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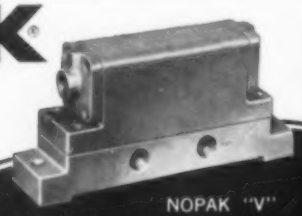
NOPAK OFFERS YOU COMPLETE AIR CIRCUITRY

another Plus Value by NOPAK



NOPAK "V"

NOPAXAM

NOPAK-MATIC

The addition of Nopaxam palm button, cam, lever and air operated valves "closes the Nopak circuit." Precise control — mechanically or electrically signaled — can now be *completely* Nopak. Singularly or in combination, Nopaxam, Nopak "V" valves and Nopak-matic valves will meet your most complex circuit requirements.

Nopak "V," 4-Way, Pilot Operated Slide Valves

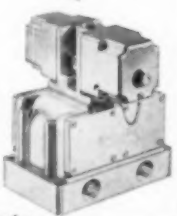
For direct or remote control. Either single or double air pilot or solenoid actuated. Simple, proven design, durable construction insure trouble free operation. See Catalog 102-A.

Nopaxam Precision Spool Valves

For air or hydraulic service to 150 psi. Pilot or mechanically operated, these valves are small, compact, easily mounted, have extremely short throw and high flow rates. See Catalog N.

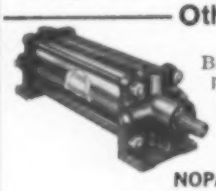
NOPAK-MATIC Poppet-Type, Pilot Operated Valves

Fast acting, high volume air valves from ¼" to 1¼" with master (air piloted), single or double solenoid. Side or bottom ported subplates or manifolds. Removing cover plates affords easy access to piston poppets housed within removable, interchangeable cartridges. 100% J.I.C. See Catalog 105.



Other NOPAK "CVA*" Products

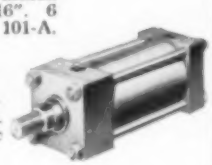
NOPAK Class 1 Cylinders



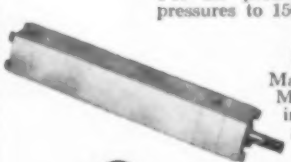
Brass Tubing and Tie-Rod Construction. For pressures to 250 psi. Choice of adjustable cushion, self-regulating or non-cushion heads. Diameters from 1½" to 16". 6 Standard Mountings. See Catalog 101-A.

NOPAK Class 6 Bore-Rated Cylinders

Compact steel plate, square head with tie-rod and honed steel tubing construction. For air pressures to 250 psi. hydraulic pressures to 1500 psi. See Catalog 106.



NOPAK Class 7, Square Barrel Cylinders



Made with pressure-cast and extruded aluminum. Mounting holes can be drilled or tapped directly into cylinder tubing. ¾" to 3" bores pressure rated for 200 psi. air or 1000 psi. oil. 7 universal mountings. See Catalog 107.

*CVA Cylinders, Valves, Accessories
NOPAK offers a complete line of Matched Fluid Power Components.

NOPAK VALVES & CYLINDERS

NOPAK DIVISION
Galland-Henning Mfg. Co.
2743 S. 31st St., Milwaukee 46, Wis.

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NEW LITERATURE

Continued from page 60

OIL LEVEL GAGES

An improved and expanded line of flush-mounting, oil level gages (Type 550) is outlined in brochure. Three standard sizes are available with 4", 6", and 8" long-sight openings. Gages can be furnished with components compatiable with petroleum products, fire resistant fluids, and a variety of other liquids.—*Federal Brass Mfg. Co., Elmira, N. Y.*

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2-WAY SOLENOID VALVE

Full 1" pipe orifice. Unique diaphragm design assures absolutely tight seating on all non-corrosive fluids. 5⅝" high. May be mounted in any position. Diaphragm can be removed without disturbing piping or electrical connections. Normally closed or open. Pressures to 125 psi. Standard, water-tight, or explosion-proof enclosures. Bulletin 8210A.—*Automatic Switch Co., Florham Park, N. J.*

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ROTARY PUMPS

Handle thick or thin liquids with positive suction lift. Side ports on right or left with a top port, or with two side ports. Interchangeable, built-in relief valves. Direct drive or built-in gear reducer. Quiet-running helical gears. Pressures to 100 psi. Capacity 40 gpm to 300 gpm. Series 3600 Catalog. —*Roper Hydraulics, Inc., Commerce, Georgia.*

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ELECTRONIC TUBE BENDER

Smooth, accurate bends by dialing angle required. Compensator dials allow quick adjustment for material spring back variation. Operates on principal of matching two electrical impulses. When spindle of the swinging arm rotates to proper angle, a control current causes bending arm to stop.—*Pines Engrg. Co., Inc., Aurora, Ill.*

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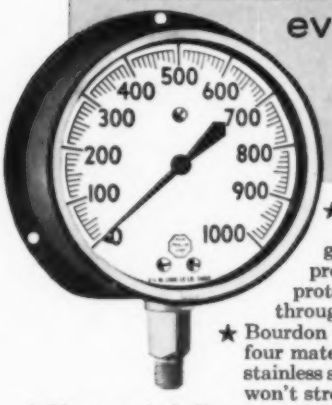
Circle **50** on Reader Service Card

Helicoid Gages give *Sustained Accuracy,* even on the toughest jobs



★ Exclusive Helicoid movement has no gears, no teeth. Shock-proof construction protects accuracy through millions of cycles.

★ Bourdon tubes available in four materials—bronze, steel, stainless steel, and K Monel—won't stretch, crack, or leak.

★ Six cases, including new solid-front safety case, meet every mounting requirement.

★ External pointer adjustment can't be jarred out of position.

★ A complete selection of gages and accessories for hydraulic, chemical, and other service.

Write for Catalog DH-65.

HELICOID GAGES

Helicoid Gage Division
American Chain & Cable Company, Inc.
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ACCO

TRU-SEAL

TEFLON SEAL

PAT. PENDING

Saves hours in piping installations

Eliminates leaks in oil, air, water, vacuum, chemical lines

Tru-Seal saves hours in assembling piping installations because it enables you to run your pipe lines in any direction you wish, quickly and easily—without having to recut and re-thread piping sections. Wherever used on air, oil, water, steam, vacuum or chemical lines, it seals perfectly at —100° F. to plus 500° F.—*without the use of pipe dope.* Its installation requires only light tightening torque, thus eliminating over-tightening damage to valves, pumps, compressors, and other fittings.

For further information write

TRU-SEAL DIVISION
FLICK-REEDY CORPORATION
7N017 York Rd., Bensenv.lle, Ill.
"Miller Fluid Power" is also a Div. of Flick-Reedy Corp.

1. Thread Tru-Seal on pipe or fitting as far as it will go hand tight. SEAL SIDE
2. Thread pipe or fitting 3 threads into port. Point in desired direction.
3. Tighten Tru-Seal to complete leakproof assembly (only light torque required).

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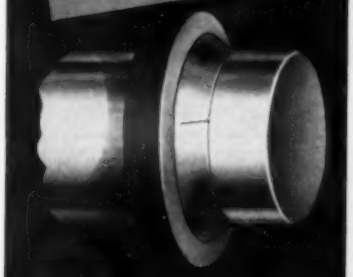
TOP QUALITY YOUR *Best* PROTECTION!



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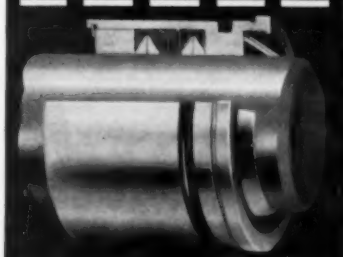
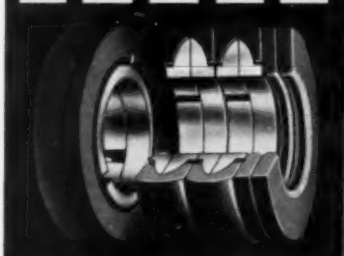
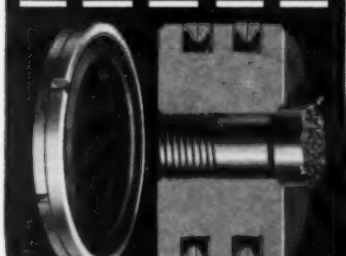
METALLIC ROD WIPERS
"Wipe off" dirt accumulation with rubber mounted, flexible bronze knife edges. Perform better, for longer.



MONOPAK CARTRIDGE
Compact, all-in-one package of packing, bearings, and rod wipers. Air or hydraulic cylinders. No machining or adjustments.



MONOPAK ROD PACKING
A highly efficient bearing and seal package for air or hydraulic use. Available in all desired sizes.



MONOPAK PISTON PACKING
A long lived, trouble-free, automotive type ring and packing for one or two piece pistons.

YOUR ASSURANCE OF BETTER PNEUMATIC OR HYDRAULIC SEALING.

Complete details and prices on request.

HYDRAULIC ACCESSORIES COMPANY

24301 Hoover Road
Warren, Michigan

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NEW LITERATURE

TUBE FITTINGS

Compact reference circular of applications and data covering O-ring seal with separate split-ring grip tube fittings. Features and advantages are covered in detail. Drawings of assembly and application. Solutions to difficult installation problems are given.—*Lenz Co., Dayton, Ohio.*

Circle **418** on Reader Service Card

MAGNETIC OIL FILTERS

Typical applications of magnetic oil filters are shown in this informative folder. Capacities of 1 and 5 gpm. Installation, maintenance, and dimension data are given.—*Sinclair Machine Products Inc., Claremont, N. H.*

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BOOSTERS

For high-pressure hydraulic systems. In single-pressure systems, entire cylinder stroke is load cycle. In dual-pressure systems, where low pressure oil goes from air-oil tank through booster to advance cylinder to load, only remaining power stroke is considered. 150-psi air, 5000-psi oil. 1½" to 14" bore. Rod sizes from ⅝" to 5½". Bulletin B-100 covers specs and types, gives selection instructions step-by-step.—*Milwaukee Cylinder Co., Cudahy, Wis.*

Circle **420** on Reader Service Card

FLEXIBLE COUPLINGS

Bulletin outlines the expanded line of Para-flex flexible cushion couplings that absorb vibration and compensate for all combinations of shaft misalignment and end float. Engineering drawings and installation pictures are included with descriptions of standard, high-speed, and flywheel types. Other data include horsepower ratings, dimensions, prices, and weights. Bulletin 901B.—*Dodge Mfg. Corp., Mishawaka, Ind.*

Circle **421** on Reader Service Card

MINIATURE PUSH BUTTONS

A revised bulletin includes new forms added to a complete line of industrial, miniature, oil-tight push buttons. Photo and diagram explain the 40% space savings using the miniature forms in enclosures or panels. Cutaway photos show pressure-type terminals, double-break contacts, and multiple oil-seals. Bulletin GEA-7127A.—*General Electric Co., Schenectady.*

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METALLIC PACKINGS, WIPERS

For pistons and rods. Made of pairs of stiff metallic sealing rings, enveloped by pliable elastic cushion rings. In operation, they are reacted upon by fluid pressure which distorts cushion rings, and creates tighter seal. This reaction is reduced as pressure subsides, reducing friction. For reciprocating motion. Seals in both directions. Acts as bearing as well as a seal, tending to hold piston and rod concentric within cylinder. Wiper assembly has two wiper rings.—*Hydraulic Accessories Co., Van Dyke, Mich.*

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DEPENDABILITY

THESE HANDS DARE TO TEST THEIR SKILL

with rigid, station-by-station inspection. CROSS hydraulic cylinder dependability is not left to chance. Every component must conform to the industry's highest standards — standards set at CROSS with faith in the workers' skills. Their pride of craftsmanship is your guarantee of quality. For a cylinder to withstand severe pressures, corrosive atmospheres — look to CROSS.

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Circle **64** on Reader Service Card

NEW! KEPNER Kepsel

cartridge type valve insert

The Check Valve that cuts costs of Design and Installation 75% and more!

- Leak Proof—At All Pressures
- Low Pressure Drop at Full Flow
- Eliminates All Threaded Connections
- Eliminates Expensive Machining

Small in size—big in capacity—simple to install—the KEPNER Kepsel Cartridge Type Check Valve is designed for positive performance. Eliminates expensive machining, finishing of fine, close tolerances, metal surfaces—dirt can't hurt it.

Write for complete technical data

*Patent Applied For

KEPNER PRODUCTS COMPANY

7321 West 59th Street Summit, Illinois

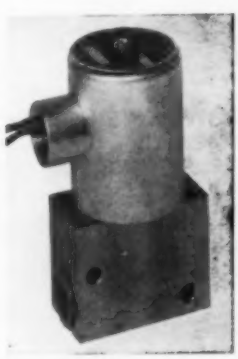
R

NEW HIGH PRESSURE SOLENOID VALVES

Two-way Solenoid Valves for Oil Pressures to 3000 psi

Two types are available: normally open, and normally closed. Both are pilot operated poppet type valves in cartridge form. They can adapt to any type of manifold or subplate. All standard AC or DC solenoids are interchangeable. Only two moving parts—poppet and plunger—make these valves less susceptible to malfunction due to contaminated systems.

All valves have free reverse flow in the de-energized position. Hardened, ground and lapped parts with oil immersed plunger assures long trouble-free operation. Many modifications to specific requirements are possible.



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FLUID POWER ACCESSORIES, INC.

Box 64 Glenview, Illinois

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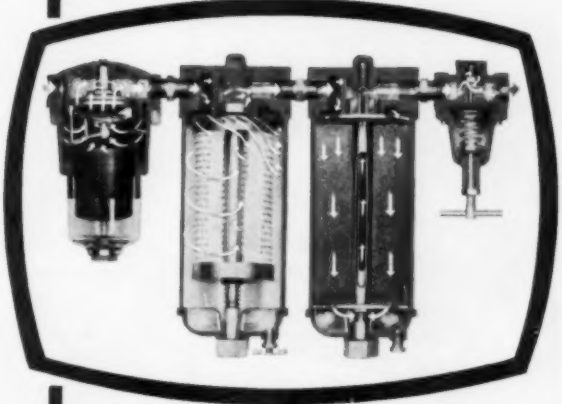
Announcing... Revolutionary NEW WILKERSON desiccant compressed air DEHYDRATOR for "instrument-pure" air



The NEW "Chem-Guard" package provides micro-clean, dehydrated oil-free air **only where needed!**

NEW Exclusive features found only in the Wilkerson "Chem-Guard":

- ★ **LOWEST PRICE** for package, application and installation. No electrical water or sewer connections needed.
- ★ **DEPENDABILITY** of "Chem-Guard" dehydrator assured because of no moving or mechanical parts.
- ★ **SIMPLIFIED, ECONOMICAL SERVICING**—No draining or reactivating is necessary. Exact amount of replacing chemicals available in vacuum packed cans.
- ★ **BUILT-IN VISIBLE INDICATOR** shows color change when servicing is required.

Your choice of 3 non-corrosive chemicals . . .

(a) Silica-Gel reduces dew point to —40° F., (60° below safe standard of 20° F)
(b) Molecular Sieve reduces dew point to —100° F.
(c) Another removes traces of oil to 10 parts per million.

WRITE TODAY for circular #1040 giving complete specifications and information

WILKERSON CORPORATION

1643 W. Mansfield Englewood, Colo.

Dedicated to keeping the NEW in pNEUmatics

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BUILDS THE BEST HEAT EXCHANGERS

AIR COOLED OIL COOLERS

Type "OH" Unit

Cooling oil and space heating, when desired, are dual advantages of Young "OH" units. Available in ten sizes. Catalog No. 3560.

LIQUID COOLED HEAT EXCHANGERS

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Young heat exchangers are used on all types of hydraulic equipment and in chemical, pharmaceutical and food processing equipment—can be furnished to ASME specifications

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Plants at Racine, Wis. and Mattoon, Ill.

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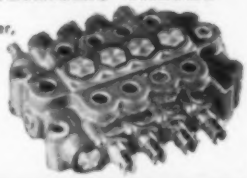
So Much Control . . .
So Little Space

HUSCO HYDRAULIC VALVES

HUSCO 4-Plunger, 45 G.P.M. Series 3200-SP Valve



- In ONE to SIX Plunger Designs
- For up to FOUR Control Positions
- Capacities from 3 to 185 G.P.M.

Other HUSCO features include:

- Power-Saving Pilot-Operated Relief Valve.
- Short Plunger Movement for more accurate control — at minimum effort.
- Check Valve Controlled circuits — Conventional or Parallel.
- Compact, precision-built for minimum space.
- Over 120 Standard Models — for unlimited modification to your needs.

Check HUSCO *First* for Hydraulic Control. Write for your copy of HUSCO'S "House of Ideas in Control Engineering" — or design assistance on your needs.

HYDRAULIC UNIT SPECIALTIES CO.
PUMPS • VALVES • CYLINDERS
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NEW LITERATURE

SPIRAL-WOUND GASKETS

Complete information in Folder AD-176 on two new types 1/16" Guardian gasket, and high temperature gasket made with ceramic filler material. Text and illustrations cover gasket construction, specifications, flange face finish, bolting data, metal temperature range, and details of gasket styles. *—Garlock Inc., Palmyra, N. Y.*

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LIMIT SWITCHES

Bulletin describes limit switches for automatic pilot control. It includes an application guide, a short section on limit switch terminology, and selection and installation guides. Discusses typical applications of lever, leverless, rotating cam, limit switches—as well as tripping forces involved for actuation of the switch. Bulletin GEA-7312—*General Electric Co., Schenectady*

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CLA
$5.95 list price 1" stroke

CLA-T
$6.95 list price 1" stroke

VALV-N-HED®
$19.45 list price 1" stroke

NEW... IMPROVED

UNIVERSAL, CLEVIS, PIVOT or STUD MOUNT 1⅛" CLAMP TYPE

AIR CYLINDERS

INEXPENSIVE ANSWER TO TOOLING and AUTOMATION!

- **COMPACT**—only 1-½ inches square.
- **VERY SHORT** overall length.
- **MOUNTS** front or rear flange, side, clevis, pivot, or stud.
- **TIE ROD** construction.
- **HEADS** machined from aluminum bar stock. Tubes, Mirror smooth brass.
- **PISTON ROD**—super-finished stainless steel for maximum corrosion resistance.
- 150 psi AIR; 250 psi hydraulic.
- **ADEQUATE** safety factor.
- **IMMEDIATE** delivery on 1", 2", and 3" stroke. Fractional or longer strokes available on short notice.

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DOUBLE ACTING, SPRING RETURN and SOLENOID OPERATED

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CYLINDERS, VALVES, ACCESSORIES

Six sections of comprehensive catalog cover cylinders, valves, industrial air equipment, accessories, technical data, and application data. Cylinder bore sizes from 1⅛" to 6". Air or hydraulic to 200 psi. Heavy-duty hydraulic to 2500 psi. Includes valve-in-head, checking, stud mount, and clamp-type cylinders. Series MV valve port sizes ⅜", ½", ¾", and 1". 3-way for single-acting cylinders, and 4-way for double-acting. Interchangeable spools and end caps. O-ring seals throughout. Includes 2-position and 3-position, direct-operating, and remote operation valves. Series BV port sizes ¼". 3-port, 3-way, and 5-port, 4-way types. Single or double solenoid. Series CRV, ⅜" ports. 3-port, 3-way, and 5-port, 4-way. —*Modernair Corp., San Leandro, Calif.*

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VALVES

Information, condensed descriptions, and specifications on bronze, iron body, and cast steel gate, globe & angle, and check valves; bar stock valves; and forged steel gate valves. Units are illustrated and specified. Catalog 10B.—*R-P&C Valve Div., American Chain & Cable Co. Inc., Reading, Pa.*

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SOLENOID VALVES (CORROSIVES)

"Solenoid Valve Selection for Corrosive Applications". Includes a discussion of solenoid valve construction, a list of over 500 corrosive chemicals commonly used in industry, valve selection charts, and a flow pressure drop chart. Manual 108.—*Valcor Engineering Corp., Kenilworth, N. J.*

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RESERVOIRS & ACCESSORIES

"Engineered Hydraulic Equipment" described Century's complete line of JIC reservoirs, oil level sight gages, and hydraulic power unit accessories. Complete dimensions are provided for each reservoir from 10- through 250-gallon models.—*Century Hydraulics, Div. Century-Detroit, Detroit.*

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POSITIVE AUTOMATIC PRESSURE CONTROL?

CHECK YOUR REQUIREMENTS AGAINST FULFLO SPECIFICATIONS

- ✓ Screw or flange models
- ✓ Pressures to 500 pounds
- ✓ Pipe sizes to 3"
- ✓ Steel, cast iron or brass bodies
- ✓ Brass, steel or stainless trim
- ✓ All-steel for extra safety

FULFLO gives you what you want in safe, trouble-free and quiet operation for any hydraulic system. Shear-closing action eliminates chattering; sliding piston gives full flow opening; distinctive construction allows easy adjustment within the valve's pressure range or change of the pressure range.

Whatever your requirement . . . for O.E.M. use or replacement service . . . there's a FULFLO Oil By-Pass Relief Valve designed just right, built right and priced right, too!

NEED A "Special"?

FULFLO can engineer a special valve to your most exacting requirements. Examples of "specials" are shown in Data Book.

FOR EXTRA CONVENIENCE

Where frequent pressure setting adjustment is needed, install a FULFLO Hand Wheel Valve. Made in a variety of styles.

TRADE MARK "FULFLO" REG. U.S. PAT. OFF.

FOR COMPLETE INFORMATION, request a copy of the FULFLO Valves Mechanical Data Book with complete specifications and engineering data.

THE FULFLO SPECIALTIES CO., INC.
415 Fancy Ave. Blanchester, Ohio

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POST SCRIPTS OF INDUSTRY

News about people, manufacturers and sales organizations

J & L div. appoints metallurgist

Limburg

Jones & Laughlin Steel Corp., Stainless and Strip Div., Detroit, has appointed Donald F. Limburg as service metallurgist. Limburg has been with Ex-Cell-O Corp., Boeing Airplane Co., Chrysler Corp. Missile Div., and Studebaker-Packard Corp.

Weatherhead appoints merchandising manager

Gerald P. Fenton has been appointed merchandising manager of The Weatherhead Co., Cleveland. Fenton will handle sales merchandising, special promotion, and new product packaging. He has served as advertising manager for The E. F. Hauserman Co. Weatherhead manufactures a complete line of fluid system components for automotive, industrial, aviation, LP-gas, ordnance, and marine applications.

Bendix appoints sales engineer

Bendix Industrial Controls Section, Bendix Corp., Detroit, has appointed Charles W. Rosner as field sales engineer. Rosner will represent the Bendix line of numerical control systems for machine tools in Philadelphia. He will assist the users of servo-type, machine control systems. Rosner has four years experience with General Atronics Corp., and two years as a lieutenant in the Industrial Engrg. Branch of the USAF.

Hicks named district sales manager

Hicks

Robert P. Hicks has been named district sales manager for S-P Mfg. Corp., Cleveland. He will handle cylinders, boosters and chucking equipment in the Philadelphia area. He has experience in industrial application of cylinders for reducing costs and increasing production.

Fluid Controls to have new building

A modern, one-story headquarters building for Fluid Controls Inc., Mentor, Ohio, is under construction in Mentor's Industrial Park area. Scheduled for completion this summer, it will centralize all administrative, marketing, and engineering facilities of the firm. It will also contain an enlarged new product development laboratory. The company designs and manufactures industrial hydraulic flow and pressure valves and control devices.

New sales managers at Pesco

Brewer

Roy C. Brewer has been named sales manager of commercial products for Pesco Products Div., Borg-Warner Corp., Bedford, Ohio. Brewer had been manager of defense sales and assistant sales manager of Wincharger Corp. He was also a field engineer for Western Electric. Donald C. Tabb was named manager of planning and sales administration. Tabb joined Pesco after retiring as commander, United States Navy, and director, Surface and Amphibious Programs Div., Office of Naval Research. He will direct all sales administration, product planning, and market analysis.

Personnel changes at Ex-Cell-O

Hughes

Ex-Cell-O Corp., Detroit, has named Russell D. Hughes assistant general manager of the Costa Mesa, California Plant of Cadillac Gage Co. Hughes joined the company in 1951 after accounting and auditing experience with several firms.

Swift is field engineer for Denison Engineering

James G. Swift has been named a field engineer for Denison Engineering Div., American Brake Shoe

Continued on page 132

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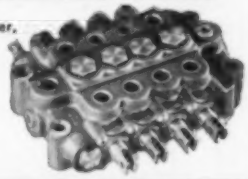
So Much Control . . .
So Little Space

HUSCO HYDRAULIC VALVES

HUSCO 4-Plunger, 45 G.P.M. Series 3200-SP Valve



- In ONE to SIX Plunger Designs
- For up to FOUR Control Positions
- Capacities from 3 to 185 G.P.M.

Other HUSCO features include:

- Power-Saving Pilot-Operated Relief Valve.
- Short Plunger Movement for more accurate control — at minimum effort.
- Check Valve Controlled circuits — Conventional or Parallel.
- Compact, precision-built for minimum space.
- Over 120 Standard Models — for unlimited modification to your needs.

Check HUSCO *First* for Hydraulic Control. Write for your copy of HUSCO'S "House of Ideas in Control Engineering" — or design assistance on your needs.

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CLA
$5.95 list price 1" stroke

CLA-T
$6.95 list price 1" stroke

NEW... IMPROVED

UNIVERSAL, CLEVIS, PIVOT or STUD MOUNT 1⅛" CLAMP TYPE

AIR CYLINDERS

- **COMPACT**—only 1-½ inches square.
- **VERY SHORT** overall length.
- **MOUNTS** front or rear flange, side, clevis, pivot, or stud.
- **TIE ROD** construction.
- **HEADS** machined from aluminum bar stock. Tubes, Mirror smooth brass.
- **PISTON ROD**—super-finished stainless steel for maximum corrosion resistance.
- 150 psi AIR; 250 psi hydraulic.
- **ADEQUATE** safety factor.
- **IMMEDIATE** delivery on 1", 2", and 3" stroke. Fractional or longer strokes available on short notice.

INEXPENSIVE ANSWER TO TOOLING and AUTOMATION!

VALV-N-HED®
$19.45 list price 1" stroke

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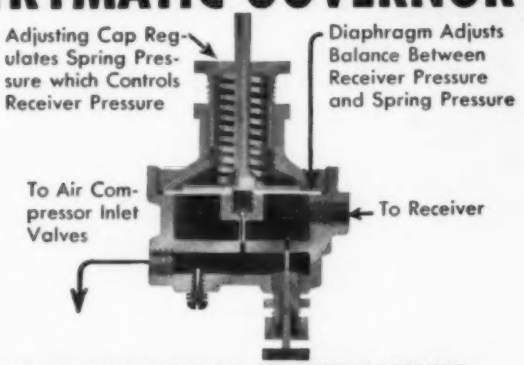
NEW FOR AIR COMPRESSORS

TRYMATIC GOVERNOR


Adjusting Cap Regulates Spring Pressure which Controls Receiver Pressure
Diaphragm Adjusts Balance Between Receiver Pressure and Spring Pressure
To Air Compressor Inlet Valves
To Receiver

- MAINTAINS UNIFORM RECEIVER PRESSURE
- BOOSTS COMPRESSOR OUTPUT UP TO 10%
- CUTS OPERATING AND MAINTENANCE COSTS
- FIELD TESTED • FITS ALL COMPRESSORS WITH UNLOADING INLET VALVES

With the Trymatic Governor, air compressors can deliver uniform receiver pressure (within one pound of any given setting) at all times. Volumetric efficiency can increase by as much as 10%. It will cut operating and maintenance costs. Has only one self-actuating moving part and requires no maintenance! Write for Bulletin , Dept. HP.

TRYMAC, Inc.
16 WEST 5th ST.
ERIE, PA.

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Just Out! Just the ticket to cut cost!

NEW SPEED CONTROL VALVE

⅛" and ¼" pipe sizes in stock now!

Now a speed control valve that regulates your cylinder movement with precision and sureness, but which lists at $3.00 and $3.25. And despite its lower costs, "CUB" features the same high quality of design and workmanship you've come to expect from Ross. "CUB'S" design stresses trouble-free operation and easy maintenance. CUB is small, aluminum and lightweight. If you use speed controls, by all means call your Ross representative or write us.

ROSS OPERATING VALVE CO.
105 E. Golden Gate Ave. • Detroit 3, Michigan

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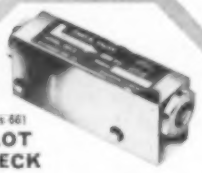
WATERMAN



Series 661
PILOT CHECK

Only 25% of line pressure required for pilot to open valve. Compact and light in weight. ¼" and ⅜" N.P.T.F., 3000 p.s.i.

Series 271
LOCK VALVES

Simple, positive, low-cost way to prevent cylinder creep due to leakage of spool valve. ¼" to ⅜" N.P.T.F., 3000 p.s.i.

Series 666
COUNTERBALANCE VALVES

Smooth, positive control of negative loads. Cylinder speed proportioned to pump output. ⅛" and 1" N.P.T.F., 3000 p.s.i.

Simplify hydraulic system design while you get improved performance. Why settle for halfway measures when you can specify a Waterman valve *designed* for these and other special purposes?

Send today for valuable Catalog 3001

NFPA

W-6118

WATERMAN HYDRAULICS CORPORATION

725 Custer Ave., Evanston, Ill.

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POST SCRIPTS OF INDUSTRY

Co., Columbus, Ohio. In his new position, he will be responsible for the sale of hydraulic pumps, controls, and systems in the southern California area and the states of Utah and Arizona. He will headquarter at the firm's Hawthorne, Calif., regional office.

Batchhelder joins Universal Hydraulics

Batchelder

Robert Batchelder has joined the Universal Hydraulics Div. of the Holan Corp., Cleveland, as divisional sales manager. He has had 12 years experience in the hydraulics field and will be headquartered in the Hartford, Conn., area. Before joining Universal, Batchelder was general sales manager of the Ward Hydronics Co., formerly Ward Tool & Machine Co. of Buffalo, N. Y.

Schmol to direct engineering at Republic

Republic Mfg. Co., Cleveland, appointed L. H. Schmohl director of engineering. He was chief engineer of Parker Fittings & Hose Div., Parker-Hannifin Corp. He is chairman of the Hydraulic Fittings Standing Subcommittee of SAE Tube, Pipe, Hose & Lubrication Fittings Committee.

Bausch named marketing director

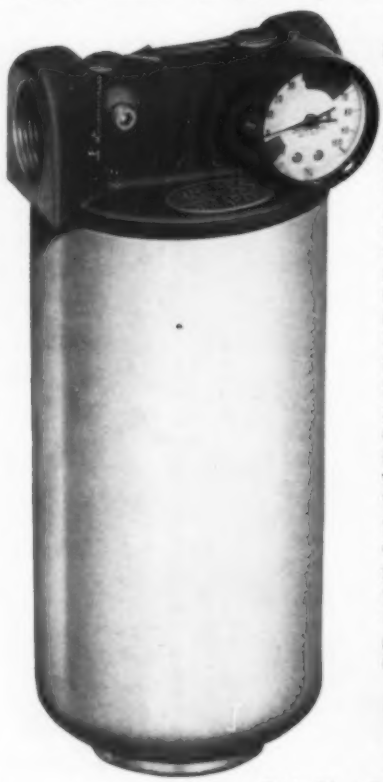
Edwin J. Bausch has been appointed director of marketing at Raymond Atchley, Inc. The firm specializes in design and manufacture of servovalves, automation systems and components. Bausch recently transferred from the Kellogg Div. of American Brake Shoe Co. where he was manager of marketing research. He brings 12 years of experience in sales promotion and management phases in the aircraft and industrial fields.

NEW FILTER

with

FILTER CONDITION INDICATOR*

eliminates need for periodic service



A quick glance at the pressure gage on this new hydraulic line filter tells you when its element needs cleaning or replacement . . . warns of impending pressure build-up *before* the built-in by-pass valve can open and allow circulation of unfiltered fluid . . . makes unnecessary the costly and wasteful procedure of inspecting or changing elements at periodic intervals.

It's a big half-gallon filter, with choice of interchangeable monel wire cloth or phenol treated paper elements. Inlet and outlet ports are full 1¼" NPTF. Pressure drop at flow rate of 60 gpm is only 5 psi when using the 200-square-inch, 100-mesh, wire cloth element.

Filter may be installed in either the suction line (between tank and pump) or the return line (between control valve and tank), and the element is easily accessible.

***Amazing fact:** *The price of this new filter is even lower than many filters without this outstanding feature.*

GRESEN MANUFACTURING CO.

GRESEN HYDRAULICS

405 - 36th AVENUE N.E., MINNEAPOLIS 18, MINN.

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INFINITELY VARIABLE DELIVERY

The Savery Variable Delivery Pump gives FLEXIBLE control which is completely POSITIVE over a wide range for use on hydraulically controlled Machinery, Agricultural and Factory lifting gear, Oil Burner equipment and hydraulics for AUTOMATION

SAVERY PUMPS have a proven record of great reliability in the METERING of chemicals and are used by VIKING ENGINEERING CO., Salford, in their renowed equipment for the production of POLYURETHANE Foams. If you will send full particulars of the properties of any chemicals you wish to pump or meter our Research Department will give you a prompt opinion of the ability of Tests can be carried out on your own materials and a candid and confidential report given with the minimum delay. our equipment to handle them.

Thomas Savery Pumps Ltd.,
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Bracebridge Street,
Birmingham 6, England
Phone Aston Cross 1316/7

Savery
HYDRAULIC PUMPS

new ROTORAM® VALVES

WITH EXCLUSIVE ROTATING STEM

for MILLIONS of TROUBLE-FREE ACTUATIONS

Treadle Valve

Knob Valve

- Low silhouette mounting
- 2024 T4 aluminum bar stock
- Rust-resistant
- Full flow air passages
- Piped exhaust ports
- Interchangeable parts
- Anodized finish

Cam Valve

Finger Valve

Pedal Valve

Hand Ball Valve

Rotoram Valves are available in 3 and 4-way models for ⅛", ¼", ⅜" and ½" pipe sizes. Special Block "V" Packing permits free ram movement, insures long valve life. Port entry from either left or right side. Ask your AIR-MITE Distributor, or write for complete details and illustrated catalog.

AIR-MITE DEVICES, INC.
4401 W. Kinzie St., Chicago 24, Ill.

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fabric impregnated V-RING sets

"U" PACKINGS

CUP PACKINGS

HOMOGENEOUS CUP PACKINGS

FLANGE PACKINGS

DOUBLE LIP WIPERS

PHENOLIC ADAPTORS

V-RING SETS

HOMOGENEOUS "U" PACKINGS

"O" RINGS

...IN ELASTOMERS TO SUIT THE APPLICATION....

Periflex has assumed a leading position in packing design and development. Latest contribution to better reciprocating sealing techniques: Famous Periflex lip-action V-ring sets are now made available

Left—Periflex pressure rings preload the packing. Give lip-action that seals at all pressures with minimum interference. Right—Extrusion-proof "phenol-fab" adaptors. Reduce cavity machining costs.

in a variety of elastomers, assuring best performance for a wide range of hydraulic media. Write for reprint of the informative article from Hydraulics & Pneumatics magazine, "Elastomers For Hydraulic Packings", written by our Technical Director.

Periflex • Inc.
HAZEL PARK MICHIGAN

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MARKET PLACE

When replying to a box number in the Market Place, address your letter to Hydraulics & Pneumatics, 812 Huron Road, Cleveland 15, Ohio. Attention: Box No.

MANUFACTURING FACILITIES

WANTED: New, proprietary products which large Western manufacturer can produce on West Coast. Facilities allow manufacture of molded rubber products, rubber-and-metal products, and straight metal products. Company has excellent rubber and metal technological experience. Good distributor organization already established. Company sales engineers trained in technical sales techniques. Large production facilities, modern machinery and equipment, engineering department, and other advantages available. We will discuss take-over of products, royalties, or licensing arrangements. We need additional products and lines to make best use of facilities and distribution channels.

Write giving full particulars as to product, patent ownership, present manufacturing operations, and other pertinent information to: G. W. Van Cleve, Vice President, Stillman Rubber Co., P. O. Box 1097, Culver City, California.

ENGINEERING-SALES OPPORTUNITY UNLIMITED

Old established but modernly aggressive central Ohio Manufacturer has 2 openings for newly graduated ME's or EE's to immediately participate in training of Hydraulic equipment, Systems, Servo Mechanisms, and Electronics. Ultimate goal, field sales engineer with future unlimited. One opening for graduate EE with 2 to 3 years practical experience for Sales Engineering liaison with Research Development department. Good mathematical and physics background essential. Starting salary commensurate with ability, aggressiveness and inclination to sales application engineering, after personal interview. Forward Resumes in strict confidence to Box No. 8161, HYDRAULICS & PNEUMATICS.

SALES REPRESENTATIVE WANTED

Wanted—Exclusive Sales Representative for CARTER CONTROLS, INC. for New England area. We pay high commissions and offer an exclusive territory in the sale of CARTER CONTROLS Air and Hydraulic Cylinders, Rotary Actuators, and Valves. Reply, giving full experience to:

CARTER CONTROLS, INC.
28 Bernice Road
Lansing, Illinois

SALES MANAGER

Prominent manufacturer of industrial hydraulic equipment seeks personnel for sales positions including position of sales manager. Reply Box No. 8261, HYDRAULICS & PNEUMATICS.

HYDRAULIC & PNEUMATIC SALES ENGINEER

We are seeking a man who is an expert in the application of industrial hydraulic and pneumatic equipment. This man has probably gained his experience as a designer of special purpose or production machinery. A knowledge of electrical control circuits is desirable. An engineering degree or equivalent experience is required, although no previous sales experience is necessary.

We will train this man to become a sales engineer for fluid power components, his territory to be within the Metropolitan New York area. He may choose compensation from either salary or commission plans.

This is an unusual opportunity for the qualified man to enter this interesting and lucrative field of sales engineering. Please send resumé, in confidence, to: M. H. Lipton, The Airoyal Company, 1990 Springfield Avenue, Maplewood, New Jersey.

AUTOMATIC TIMERS

A complete line for industrial applications and original equipment

INDUSTRIAL TIMER CORPORATION

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Canada: Sperry Gyroscope Ottawa Ltd.
3 Hamilton Ave., Ottawa, Can. • PA 8-4681

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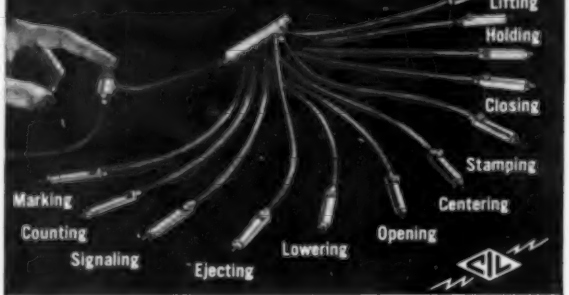
FINGERS of Automation



Industry's ONLY Complete Line of Miniature Cylinders, Valves and Accessories!

If you have a fluid power design problem where savings in space, weight, or cost must be solved, learn how CLIPPARD Miniature Air and Hydraulic devices can help you. Included in industry's ONLY COMPLETE miniature line are cylinders of ⅜" thru ⅞" bore, valves, valve solenoids, flow controls, quick connects, programmers, manifolds, fittings, tubing and accessories. All are interchangeable and are limited in usefulness only by the scope of your imagination. WRITE FOR COMPLETE CATALOGING, NOW!

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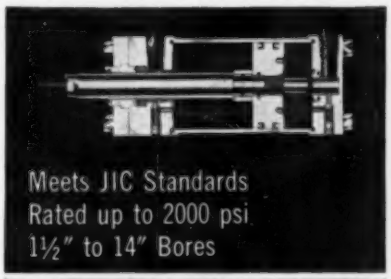

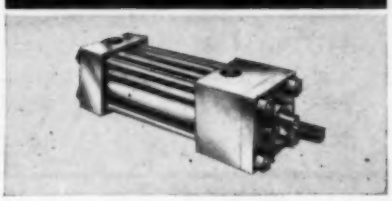

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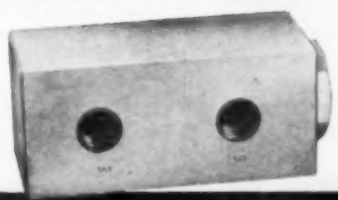

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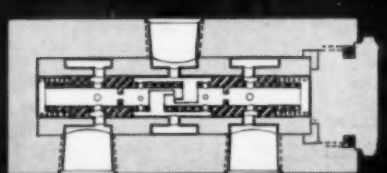

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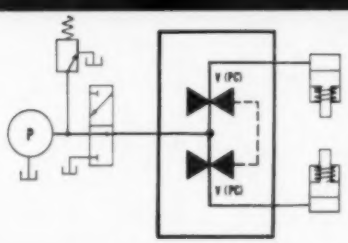

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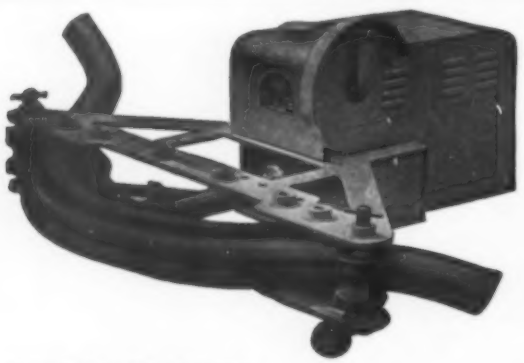

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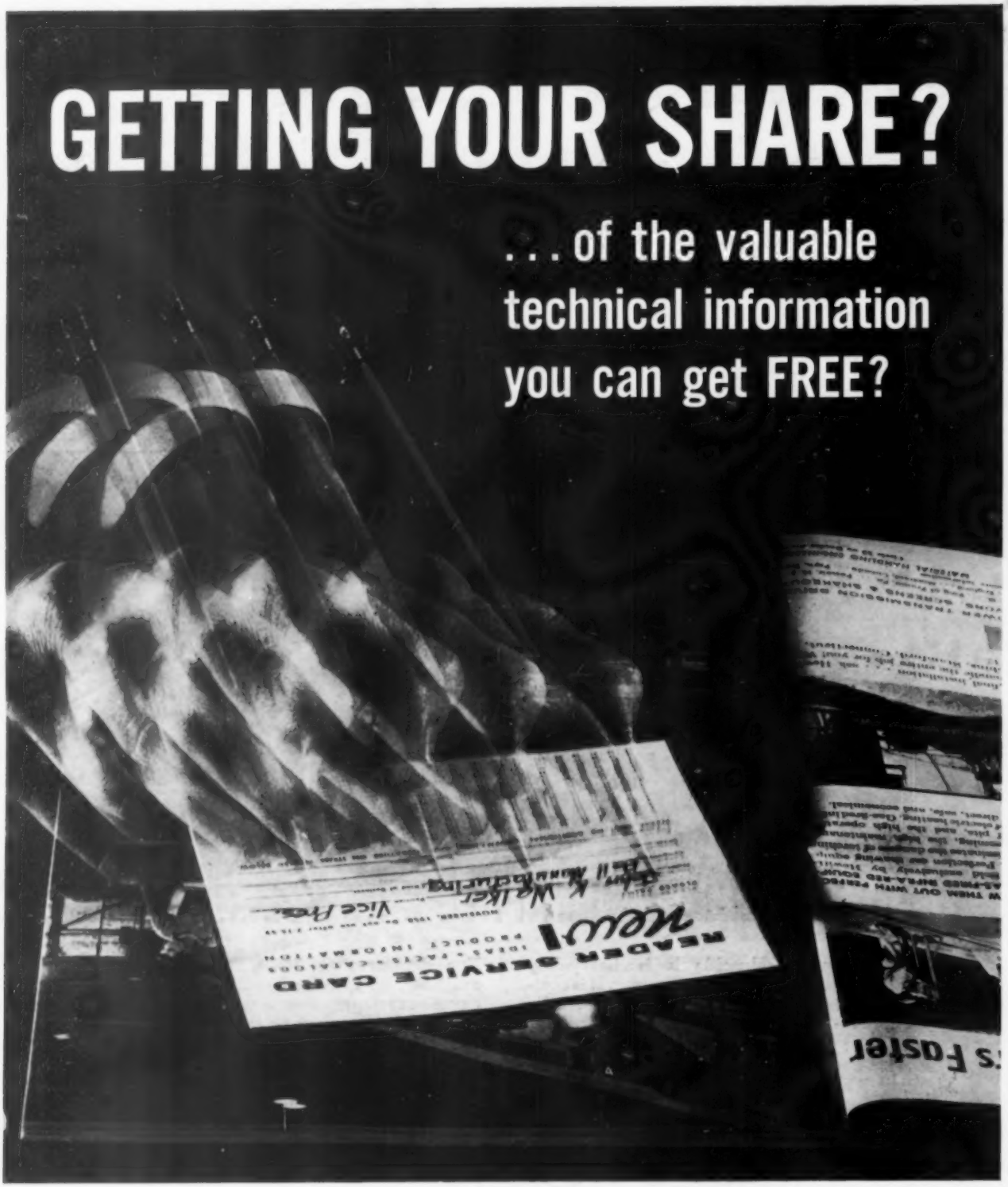

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